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WORCESTER REED WARNER, ASTRONOMICAL ENGINEER

By CLYDE FISHER.

"Blessed are they who have the gift of making friends, for it is one of God's best gifts. It involves many things, but above all, the power of going out of one's self, and appreciating whatever is noble and loving in another."—THOMAS HUGHES.

"Our Friend, Worcester Reed Warner" might have been appropriately selected as the title of this article, for all who knew this man were his devoted friends. This includes especially his professional colleagues in mechanical engineering and in astronomy, although he would not have admitted that he was a professional astronomer; but it also includes his co-workers in other branches of engineering and thousands of persons who came under his influence through their interest in the stars or because of his unselfish kindness and inspiring personality. Truly he had a host of friends scattered over the world.

When it was reported that Mr. Warner had passed away on June 25, 1929, in the ancient town of Eisenach, Saxe-Weimar, Germany, the news could hardly be credited, for he was one of those who are expected to live on and on. He was tall and straight and carried his years so well,—was so alert and alive, that even his closest friends could scarce believe that he had passed the eightieth milestone three years before. It seemed that he was no more than three score, or possibly three score and ten. In truth, however, he was more than a month past his eighty-third birthday at the time of his death.

Early in May he had left his home in Tarrytown-on-Hudson with Mrs. Warner and their daughter, Miss Helen B. Warner, on his nineteenth European trip. They had visited Italy and Austria and had begun their journey through Germany. Mrs. Warner and their daughter were with him during his brief illness in Eisenach.

On April 23, just a few days before the date of sailing, the writer had the privilege of lunching with Mr. Warner at the Engineer's Club in New York City, having been invited in order to talk over a paper on celestial mechanics which the latter had recently finished. However, it was the writer's suspicion that this ostensible excuse had for its object the making of Mr. Warner's kindness less obvious,—to make the communion, delightful as it was, even more comfortable. At this luncheon, Mr. Warner chatted about his contemplated trip abroad in his usual cheerful manner, indicating that he was looking forward to it with pleasant anticipations.

By coincidence, the passing of Mr. Warner occurred just ten days after the death of his close friend, Charles Francis Brush, inventor of the arc-light,—both of these outstanding engineers having lived and done the principal part of their life work in Cleveland, Ohio. By further coincidence, the death of Mr. Warner occurred just one calendar month after that of Garrett P. Serviss, who by his lectures and his writing had done so much to popularize the subject of astronomy. Mr. Serviss and Mr. Warner were the only honorary members of the Amateur Astronomers Association.

Worcester Reed Warner was born in Cummington, Hampshire County, Massachusetts, May 16, 1846, the son of Franklin J. and Vesta Wales (Reed) Warner. His birthplace, on the eastern slope of the Berkshires, between Pittsfield and Northampton, Massachusetts, had been the Warner homestead for four generations. Like the poet, William Cullen Bryant, who was also born in Cummington, Massachusetts, Worcester Reed Warner was of Mayflower ancestry. Among the latter's forebears were officers in both Colonial and Revolutionary armies. Franklin J. Warner, his father, was a more than ordinarily able and prosperous farmer, and evidently Worcester inherited from him his own business ability and mechanical tastes. The mother, Vesta W. R. Warner, was a lover of books and was a woman of exceptional intelligence. It is equally evident that Worcester inherited his love of science from her. On account of his mother's first name, that of the brightest of the minor planets, one cannot but wonder whether the interest in astronomy did not date back to a former generation on his maternal side.

During his boyhood years he and his two brothers, the younger of whom died at ten, worked with their father on the Warner farm; but early in life Worcester's liking for mechanics manifested itself and his happiest hours were spent in the carpenter shop over the carriage-house back of his home. One of his first productions in this shop was a lathe built from odds and ends.

To obtain working capital to carry on his youthful experiments, Worcester took as his first job that of building the fire in the little red brick district schoolhouse he attended. He contracted with the school officials to start the fire every morning an hour before school convened, and in return received a salary of two dollars per term.

According to the *Cleveland Plain Dealer* (June 26, 1929), to which source I am indebted for a number of facts concerning Mr. Warner's life, he listed as his first invention a ventilated beehive. This was built not only with the well-being of the bees in mind, but also that the young scientist might observe how they worked. Accordingly he fitted the ventilated hive with glass plates, but soon discovered that the insects plastered these over with wax, "teaching me," he said, "that bees like to work in the dark."

Mr. Guy Hubbard, in his memorial article in *Mechanical Engineering* (August, 1929), to which I am also indebted for biographical data,

says: "Worcester Warner drew his first astronomical inspiration from a book by Prof. O. M. Mitchell, called 'Planetary and Stellar Worlds,' which was presented to him by his parents." The writer has heard him state that he had received great help from "The Geography of the Heavens," by Elijah H. Burritt, and has heard him tell with dramatic tenderness how his mother had been an inspiration to him in astronomy.

At one of the early meetings of the Amateur Astronomers Association in the American Museum of Natural History, Mr. Warner told the following story, one which he loved to tell and which he always told with much feeling.

"In 1882 there lived an elderly couple in a farm-house on the eastern slope of the Berkshires in Massachusetts. The husband was working in a field near the house. The wife, who always kept track of astronomical happenings by means of the almanac, was preparing to observe a transit of Venus, which was not due to happen again until the year 2004. She darkened the room having an eastern window, for Venus was to cross the face of the sun in the morning. Then she made a small, round hole through the green linen window-shade, and hung a bed-sheet on the wall opposite the window, upon which to catch the image of the sun made through the pin-hole. Soon after everything was in readiness, when the image of the sun showed clear and round, as a relief to her suspense there appeared on the edge of the sun a small, round, black dot. She was profoundly thrilled, for she had been watching the clock and Venus had appeared strictly according to schedule. She ran out into the field near by to fetch her husband. She caught him by the arm and urged him to hurry. When they came into the darkened room, the husband remarked that it was only a little spot,—but they both watched it and were soon convinced that the black spot was moving. In fact, they watched it pass clear across the image of the sun. Thus, with this primitive apparatus, these two old people observed the last transit of Venus.

"That old New England farmer was my father, and his wife was my mother."

In school, young Worcester Warner showed keen delight in the study of physics and of mathematics. At the age of nineteen he completed his schooling with a three-month term under G. Stanley Hall, who was then a student at Williams College, and later president of Clark University.

Worcester Warner had no liking for farming as a life work, so in the autumn of 1865 he secured his first employment, which was in the drafting room of the American Safety Steam and Engine Company, Boston. He was selected for this work in competition with about a hundred other boys,—George B. Brayton, the engineer, having been favorably impressed by young Warner's self-schooling in mechanics. The pay was five dollars per week.

In the spring of 1866 the offices of this company were removed to Exeter, New Hampshire, and Worcester Warner was taken along. Here he worked in the shop as well as in the drafting room and office—still

at five dollars per week—and here he first met Ambrose Swasey, whom he described as "the brightest of the lot." In the spring of 1869 the two boys, Warner and Swasey, decided to start out together, and upon application were employed by the Pratt and Whitney Company in Hartford, Connecticut. In less than two years both were given positions as foremen. Mr. Swasey eventually had charge of the gear-cutting department, while Mr. Warner had charge of a machine-tool-building department, and both engaged in an activity called "contract work," which played a large part in developing individual manufacturing talent in the old New England shops. Under this system the company furnished the men and the materials, and charged the labor against the contract. If the job was finished at a cost less than the contract, the contractor pocketed the difference as his profit. Otherwise the loss was charged against the next profit. The successful contractor, as Mr. Guy Hubbard explains, had to be a close estimater, an able handler of men, and a good mechanic. Both Mr. Warner and Mr. Swasey were notably successful in contracting, and though neither drew over three dollars per day as salary, they managed to accumulate a joint capital of $12,000 during their eleven years with Pratt and Whitney.

On account of his remarkable talent for making acquaintances, and due to his fine appearance, Worcester Warner was given charge of the Pratt and Whitney machinery exhibition in Boston in 1873. Here by the judicious operation of a fast screw machine next to an aisle, and by the liberal distribution of samples of its work, he kept a crowd around the exhibit, and had the satisfaction of wiring to the plant, "You are awarded the first and only gold medal."

In 1876 he was given charge of the Pratt and Whitney exhibit at the Centennial Exposition in Philadelphia. In 1878 he made his first trip to Europe, on which visit he demonstrated his uncanny ability to "get into places." When Charles Churchill and Company were unable to get him a pass into the famous Whitworth works, he went to Newcastle "on his own" and so impressed the Whitworth officials that they conducted him through the whole "forbidden" plant.

In 1880 Worcester Reed Warner and Ambrose Swasey decided to leave the Pratt and Whitney Company in order to establish a machine business of their own in the Middle West. They first tried Chicago, but turned to Cleveland upon the convincing advice of Thomas White, the sewing-machine manufacturer, and others. In 1881 they established themselves in Cleveland. In addition to their own $12,000 they borrowed $7,000 from a willing Cleveland bank before their business got under way, and that was the only borrowed capital they ever needed.

From the very beginning the Warner and Swasey Company has been widely known in two seemingly entirely unrelated fields—turret lathes and astronomical telescopes. During the few months they were located in Chicago, they received orders for several small telescopes such as Mr. Warner had previously made for his own use. Their first order in Cleveland was for ten hand-lathes. During the early years of the plant,

machines for milling the cams on sewing machines were built, and later a horizontal boring machine was introduced. Turret lathes were, from the first, the principal product of the firm. A standard line of these machines was developed, since the bicycle era brought a greatly increased demand for devices of this type.

Astronomers are more interested in Warner and Swasey as builders of telescopes, and they achieved the distinction on three separate occasions of designing and building the world's largest telescope: first, for the University of California, the Lick telescope, installed on Mt. Hamilton, an instrument with a 36-inch object-glass; second, for the University of Chicago, the Yerkes telescope, installed at Williams Bay, Wisconsin, an instrument with a 40-inch object-glass; third, for the Dominion Astrophysical Observatory at Vancouver, a 72-inch reflecting telescope.

After more than thirty-five years the Yerkes telescope remains the largest refracting telescope in use in the world. It is true that the Vancouver reflector has been surpassed by the 100-inch Hooker reflecting telescope of the Mt. Wilson Observatory, and this bids fair to be outstripped by the proposed 200-inch reflecting telescope projected by the California Institute of Technology. But size is by no means the only criterion by which the astronomical engineer's work is judged. It is believed by some, whose opinion is worthy of note, that the 72-inch reflector in Vancouver, British Columbia, is the finest and best telescope in the world, regardless of size. Warner and Swasey also built the 60-inch reflector for the Argentine National Observatory, and the present mounting for the 26-inch refractor of the U. S. Naval Observatory.

On April 17, 1929, in a lecture entitled "A Starry Night at the Lick Observatory," given before the Amateur Astronomers Association at the American Museum of Natural History, Mr. Warner described a reception tendered to himself and Mrs. Warner at the Lick Observatory some time after the great telescope had been installed. The Director, Dr. W.W. Campbell (now President of the University of California), formally turned over to Mr. Warner the keys of the Observatory, and told him that all was his, and asked him what the staff could do for him. Mr. Warner, thus challenged, asked if he could be shown through the big Lick telescope, which his firm had designed and built, the following objects, which he had never seen: the fifth satellite of Jupiter, the star within the ring-nebula in Lyra, the globular star-cluster in Hercules so magnified as to show the dark sky between the stars in the center, and the double star Gamma Andromedae splitting the fainter companion into two stars which are less than one second of arc apart. Dr. Campbell admitted that this was a rather large order, but immediately promised all except, possibly, the fifth satellite of Jupiter. After dispatching one of the staff to look up the ephemeris of Jupiter's fifth moon, it was found that this too was in position to be seen. Mr. Warner's unusual request was thus completely fulfilled, and we can understand how this full performance gave him a thrill which he never forgot.

It is a remarkable example of the trust of one man in another that for twenty years Warner and Swasey conducted their business without any form of written agreement. The Warner and Swasey Company was incorporated in 1900, and these incorporation papers actually constitute their first written agreement.

In addition to his outstanding success as an engineer and manufacturer, Mr. Warner—during his thirty years of residence in Cleveland—became one of the leading men of that city in civic and financial affairs. He served as a director of the Guardian Trust Company, and of the Society for Savings; as a trustee of Western Reserve University and of Case School of Applied Science; as one of the early presidents of the Cleveland Chamber of Commerce and of the Civil Engineers' Club (now the Cleveland Engineering Society); and he was a member of the Union Club and of the University Club.

In 1890 Mr. Warner married Miss Cornelia F. Blakemore, of Philadelphia, who was an able and popular associate in all of his activities from that time on.

A charter member of the American Society of Mechanical Engineers, Mr. Warner was its president in 1897. He was a member of the British Astronomical Society, a fellow of the Royal Astronomical Society, a fellow of the American Association for the Advancement of Science, member of the American Astronomical Society, an honorary member of the Amateur Astronomers Association, and a member of the Engineer's Club of New York. In 1925 he was made an honorary member of the American Society of Mechanical Engineers, at which time Herbert Hoover was likewise recognized for his engineering achievements. Mr. Charles R. Crane once referred to Mr. Warner as "the brightest mechanic in America."

In 1897 he was awarded the degree of Doctor of Mechanical Science by the University of Western Pennsylvania (now University of Pittsburgh), and in 1925 he was made Doctor of Engineering by Case School of Applied Science.

To enumerate Mr. Warner's many benefactions would make a long list. He contributed liberally to educational institutions and to churches, and among his gifts to the Cleveland Museum of Art is a part of his collection of rare Chinese porcelains, bronzes, jades, and other curios gathered during his travels. Mr. Warner was so honestly modest that one would never have learned from him that he became, in his later years, a recognized connoisseur as well as collector of Chinese art-objects. Dr. John C. Ferguson, a high authority upon this subject, says of Mr. Warner: "None of us . . . can ever forget his enthusiastic appreciation of all that was beautiful and, better still, of all that was good [in art]. He had a notable share in bringing the treasures of Chinese Art to the attention of our American people."

Among the things he did for his native village of Cummington was to give it a water system, electric power and light, and a Community House, the latter being notable in that neither without nor within ap-

pears in any place the name of the donor. The most prized ornament of the Community House is the exquisite replica of the Bryant Vase, presented in 1920, a fitting tribute from one son of Cummington, eminent in the world of business and applied science, to that other son, immortal in American literature.

Mr. Warner retired from active business in 1911, and left Cleveland to make his home in Tarrytown, New York. As a benefactor of that community, he is second only to his friend and neighbor, Mr. John D. Rockefeller, Sr. Recently Mr. Warner gave to Tarrytown a $250,000 library, and later endowed it with $50,000 for the purchase of books.

Many friends have enjoyed the warm hospitality of Mr. and Mrs. Warner in their beautiful Tarrytown home, Hillholm, and have been privileged to look at the stars through the telescope in his private observatory, grateful that Mr. Warner's mother had inspired him in the field of astronomy. All of his great host of friends admire him for his achievements, but more than this they are thankful for Worcester Reed Warner, the genuine, human man, whom they had the privilege of knowing.

> *"So long as we love, we serve; so long as we are loved by others I would almost say that we are indispensable, and no man is useless while he has a friend."*—Robert Louis Stevenson.

AN ARTISTIC PRIVATE OBSERVATORY

By ROBERT E. MILLARD.

My chief reason for deciding to build an observatory to house my 4-inch Bausch & Lomb equatorial was an economic one.

Heretofore my use of the telescope was largely confined to the summer time with its quiet atmosphere and balmy weather; but the autumn, winter and spring winds, causing troublesome vibration, and the cold damp ground causing cold feet and strained conjugal relations, impressed upon me the need for a sheltered place from which to commune with the goddess Urania.

Although the thought uppermost in my mind was to get a full measure of efficiency from the excellent instrument, the appeal to my better half for her endorsement of the project was based upon hygienic grounds; and it was successful.

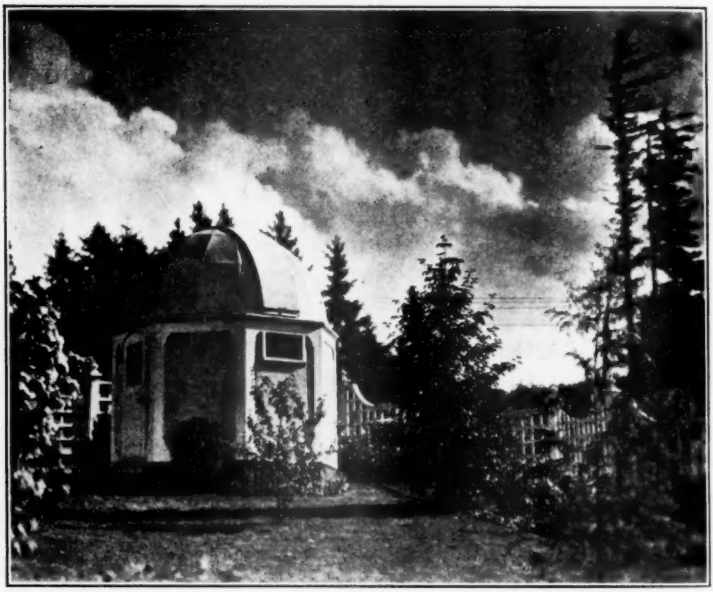
As my home is in a scenic part of the west side residential district (1000 feet above the city) it was necessary to plan a building which would possess architectural beauty, while it was also desirable to keep the cost as low as good materials and workmanship would permit.

I placed the matter in the hands of Mr. J. N. Justus who designed and built the observatory along the lines I suggested, achieving a structure which is widely admired as a model of beauty and utility.

The house is octagonal in shape, of frame construction, and is supported by eight brick piers on concrete footings.

The outside walls are of celotex panels, which three coats of paint render impervious to the rain. The studding is covered inside by a wainscoting of selected fir, stained and varnished, and there is a substantial floor laid upon 2x6 inch joists built around the concrete telescope pier.

The cornice plate is of 2x12-inch stock cut octagonal on the outside and circular inside. A guard rail of ½x8-inch spruce in two-ply lamiantion is bent around the inside of the cornice plate to hold the dome in



Mr. Millard's Observatory.

place, and a 4-inch track of heavy galvanized iron is laid upon the cornice plate, over which and up to the top of the guard rail is laid a flashing or covering of lighter iron.

The curved rafters of two-ply laminated 1-inch fir for the dome were cut at the mill, as well as the lower ring or plate to which they are attached. The latter is of three-ply lamination to give it greater rigidity. The rafters are joined by two circular rows of braces extending around the dome.

The dome, which is covered with 16-ounce duck waterproofed and painted, is mounted on twelve ball-bearing roller-skate wheels, while eight more wheels act as thrust bearings to reduce friction against the

guard rail. This valuable idea, as well as that of using celotex for the walls, was obtained from the excellent article of Charles D. Higgs in the August-September, 1928, issue of POPULAR ASTRONOMY.

INTERIOR OF MR. MILLARD'S OBSERVATORY.

The slit is twenty inches wide, and is carried only to the zenith, to simplify the construction of the type of shutter which we decided upon. The latter is of galvanized iron, and is extremely simple, having the sides bent or crimped around the edges of the galvanized strap iron

tracks upon which it slides up over the dome, operated by a rope and pulley from inside. At the top and bottom lateral strips of light angle iron are riveted for stiffening. The advantage of this type of shutter is that it is simpler, cheaper, more weather tight, and does not rattle in the wind. A little grease on the tracks is all that is needed to insure easy operation; and a further advantage is that it is not always necessary to open the slit all the way up.

Two street-car straps with white, sanitary shields are attached to the rafters, one at the slit and one opposite, by means of which a comfortable grip is obtained, and the dome is easily turned.

A seat and a writing desk, both of which can be folded up flat against the wall, comprise the furniture, while shelves, a book container and an eyepiece rack are built into the wall.

The inside diameter of the room is ten feet, and from the floor to top of the dome is eleven feet six inches.

The dome was built on the ground, and when all was ready, some of the neighbors came over and six of us lifted it into place. The event was one which the neighborhood had awaited with keen interest for two weeks, and was consummated with as much eclat as the launching of a ship.

All of the construction work was done by hired help except the painting which I did myself. The total cost was $375.00.

PORTLAND, OREGON.

COSMOGONY

God's finger stirred the ether,
Lo, a universe was born!
Nor time, nor space, had meaning
Till God made the night and morn.

A light sprang out from darkness,
Yet the fire-mist had no form
Till eon followed eon
And the nebulae were born.

The cosmic clouds contracted
Under gravitation's pull;
The stars were formed, and planets,
And the crescent moon, and full.

The meteors and comets,
The calcium clouds in space,
The cosmic dust and novae
Each has found its ordered place.

One common law eternal
Pervades all space and time;
It rules the stars and atoms,
For its birth is in God's mind.

—LESLIE C. BEARD.

Hagerstown, Maryland, March 8, 1930.

REPORT ON MARS, NO. 44

By WILLIAM H. PICKERING.

The Axis of Mars.

The position of the axis of Mars is a matter of primary importance to the Martian investigator. The drawings of practically all the most active observers of that planet throughout the world, twelve in all, are given in Reports Nos. **41** and **43**. Nearly all of them show that considerable and easily measurable changes have occurred in the shapes and positions of a few of the markings. In order to know definitely quantitatively what these changes are, and in what directions the markings move, it is necessary that we should know the position of the planet's axis with all possible accuracy. Three astronomers during the present century have located the axis by measures of the planet, but by three entirely distinct methods, and from their investigations it is certain that the position at present given in the *Ephemeris* is at least as much as one degree, measured on a great circle, out of the way. By meaning their results in different ways it appears that the position of the axis is now known within less than fifteen minutes of arc, or 9 miles measured upon the surface of the planet. It does not appear plausible that all three observers should be liable to the same systematic errors.

Lowell in 1912 employed the classical method of Schiaparelli, which depends on determining the position angles of the two polar caps. He gives four different results differing in the extreme cases by less than a degree of arc in right ascension, and by only 0°.3 in declination. He does not state which one of the four he prefers, but we have selected the one which combined his latest published observations in 1911 with all his previous ones. (*Lowell Observatory Bulletin*, **56**, 32.) The writer in 1927 combined the drawings of detail of 10 particularly well seen points out of 100, all located near the central meridian on 187 selected drawings, made at six of the seven apparitions between the years 1914 and 1926 inclusive, and from their varying positions on the disk, caused by the apparent shifting of the planet's axis, deduced its position. (Report on Mars, **40**, 8.) In the choice of these points particular attention was given to select those which the measures showed as giving the least evidence of proper motion over the surface of the planet. (Reports Nos. **33**, 7, and **40**, 7.) Trumpler also in 1927, determined the position of the axis from measures of planetary detail, but necessarily remote from the central meridian, as shown upon photographs taken during 1924, the year of closest approach of the planet. (*Lick Observatory Bulletin*, **387**, 33.) Trumpler on that page gives a reference to Lowell's observations as being published in *Lowell Bulletin* No. **2**. They were actually published, and will be found as stated above in *Bulletin* No. **56**.

We will now consider first what we may call the Polar Cap method. During the nine years between 1877 and 1886 Schiaparelli made four determinations of the location of the axis. They ranged over 3° of right ascension and 2° of declination, and were centered at 319°.9, +54°.9. These and the following positions are given for the epoch of 1905. (See map, Figure 2.) Schiaparelli's position, however, lies off the map, and the following positions are not marked upon it. Lohse on the ten years between 1884 and 1894 also made four determinations of the location of the axis, ranging between 4° of right ascension and 2° of declination, centering at 317°.2 and +54°.4. Cerulli made a determination dependent on the apparitions of 1896 and 1898, giving the position as in 318°.6, +54°.1. Between 1901 and 1905, by combining his own observations in different ways, Lowell made four determinations of the position ranging between 2° of right ascension and 1°.5 of declination, and centered at 316°.0, +54°.6. These must not be confused with his later four above mentioned. H. Struve in 1895 also made a determination based on the orbits of the satellites, locating the pole in 1880 in 317°.0, +52°.5. Trumpler gives Struve's position in 1925 as in 312°.6, +52°.8, a result which I have not been able to verify, and is doubtless a misprint. From all these determinations Lowell located the probable position of the pole in 1905 in 317°.5, +54°.5 (*Lowell Bulletin,* **24**, 160), and this value was adopted by the *American Ephemeris* in 1909, and has been in use ever since. The shift in the position of the pole in twenty years due to precession amounts to only +0°.13 in α, and +0°.07 in δ, hence for the *Ephemeris* pole in 1925 we have α 317°.63, δ +54°.57.

We see that this method of location gives rather divergent results. This is due in part to the fact that when the polar caps are large, and extend into comparatively low latitudes they melt in the noonday hours, so that at sunset their rims are in an appreciably higher latitude than at sunrise. Moreover, both caps are often irregular in shape, and marked irregularities of outline sometimes occur. This is especially noticeable in the case of the southern cap, which is quite eccentrically located with regard to the planet's pole. Another cause further limiting the range of the measurements is the sometimes gibbous shape of the planet, when a portion of the cap may remain unillumined on the dark limb. Even the mere approach of the terminator by darkening the disk is found to involve considerable subjective errors. (Report No. **32**, 1.) As a result of these limitations we have found that the position angle of the northern cap can only be accurately measured between solar longitudes ☉60° and 130°, and the position angle of the southern one between ☉230° and 295°. Only 135° out of the whole orbit of the planet can therefore properly be used, and often not that. The observations are therefore confined to the times when the planet is near its solstices. But at these times when the caps are small, it is sometimes impossible to tell whether they are due to snow or cloud, and as Lowell and others have shown, they are then sometimes subject to considerable shifts of position, in

one case from longitude 30° to 54° according to *Lowell Bulletin* **33**, 201.

By the Photographic method as used by Trumpler the photographic plate was placed in the direct focus of the telescope, and the planet's image was therefore never more than 2 millimeters in diameter. The pole was located by means of points situated on the boundary between the light and dark regions, and also by measures of the location of numerous lakes, some situated in the light, and others in the darker regions of the planet. In order to be of any particular use at the present day, we should be able to determine the position of the pole within at least one degree, or 37 miles measured on the surface of the planet, or 0.019 millimeters on the scale of Trumpler's plates when Mars was nearest us, and 25″ in diameter. This distance corresponds to a distance of 0″.22. There is no question but that a star can be readily measured with this degree of accuracy, because its image is circular, and is for instruments of long focus about 1″ in diameter, but it is not so clear that it is possible in the case of a relatively faint, indistinct, sometimes irregular, planetary detail. (See Trumpler's enlarged photographs.) These prints are 25 millimeters in diameter, and the distance between the silver grains ranges between 0.5 and 1.0 millimeter, average distance 0.7 millimeter. Dividing this last figure by 12.5 gives us the sine of 3°.2, or 120 miles as the distance between the grains measured on a great circle on the planet even when Mars was nearest to us. Trumpler made so many measures, however, that the resulting error of the mean is much less than this implies.

With regard to what we may call the Apparitional method of locating the planet's axis, we probably cannot do better than refer to Dr. Trumpler's criticism of some of my earlier results. He mentions the well-known fact that the estimates of the center of a round disk may be, and usually are, either too high or too low, and thinks that this should affect my measures. As I have pointed out in Report No. **40**, 8, which was in the printer's hands when Trumpler's paper was published, and which therefore he had not seen, this systematic error, unless my eye had changed, would have no effect whatever upon the computed position of the axis, but would only affect the latitude of the assumed equator. This effect was measured, and found to amount to a deviation of —0°.4 of latitude, or 15 miles measured on the surface of the planet. The present investigation reduces this figure to +0°.3, or 11 miles.

It may be mentioned here that Table II in Report No. **40** is not very clear, partly because it is too much condensed, and partly because the spacing of the successive columns as printed is liable to confuse the reader. It was published in order to show that even including the measures made in 1922 in the general computation, these results could not be properly combined with those of the six other apparitions. Table I of the present Report is computed in precisely the same manner, but 1922 is left out entirely in the general computation, and only shown in the special columns devoted to that year. Why we believe that it should

TABLE I.

LATITUDES OF THE STATIONS.

Sta.	Name	M	1914 ⊙	1914 L	1914 L—M	1916 ⊙	1916 L	1916 L—M	1918 ⊙	1918 L	1918 L—M
7	Thymiamata f.	— 2°0	8°6	— 2°0	0°0	53°0	— 2°2	—0°2	89°4	— 2°1	—0°1
8	Aromatum S. p.	— 2.8	6.4	— 3.7	—0.9	55.8	— 3.2	—0.4	83.1	— 1.7	+1.1
23	Maeisia	—11.9	14.7	—14.8	—2.9	58.8	—10.1	+1.8	86.0	—11.5	+0.4
24	Solis N.	—22.9	14.2	—22.9	0.0	58.8	—24.2	—1.3	86.0	—21.6	+1.3
43	Titanum N.	—19.8	17.5	—19.8	0.0	50.6	—21.5	—1.7	87.2	—18.6	+1.2
46	Aesculapius	— 0.3	10.9	+ 2.3	+2.6	53.6	— 0.7	—0.4	97.1	— 3.1	—2.8
50	Laestrigonum N.	—14.8	24.1	—19.5	—4.7	70.2	—16.5	—1.7	95.7	—13.8	+1.0
58	Cimmerium N.	— 2.7	14.6	— 1.7	+1.0	44.2	— 3.0	—0.3	88.2	— 2.8	—0.1
94	Edom S.	— 3.0	17.7	— 5.2	—2.2	47.7	— 2.1	+0.9	90.2	— 2.7	+0.3
98	Furca N. f.	+ 8.0	4.7	+ 5.5	—2.5	63.2	+ 9.5	+1.5	89.5	+ 6.9	—1.1
	Mean		13.3		—0.96	55.6		—0.18	89.2		+0.12

TABLE I—CONTINUED.

LATITUDES OF THE STATIONS.

Sta.	1920 ⊙	1920 L	1920 L—M	1922 ⊙	1922 L	1922 L—M	1924 ⊙	1924 L	1924 L—M	1926 ⊙	1926 L	1926 L—M
7	130°1	— 1°8	+0°2	181°4	+ 1°6	+3°6	246°7	— 1°4	+0°6	300°4	— 1°4	+0°6
8	122.2	— 2.4	+0.4	192.8	+ 2.6	+5.4	244.2	— 3.4	—0.6	305.1	— 5.8	—3.0
23	130.2	—11.1	+0.8	182.6	—10.7	+1.2	257.9	—10.5	+1.4	326.0	— 8.2	+3.7
24	111.7	—22.9	0.0	181.5	—18.6	+4.3	237.0	—22.5	+0.4	[309.8	—17.4	+5.5]
43	143.6	—18.5	+1.3	170.1	—13.9	+5.9	241.7	—14.1	+5.7	310.9	—21.6	—1.8
46	143.6	+ 0.3	+0.6	197.8	+ 3.8	+4.1	234.3	— 2.5	—2.2	316.4	— 0.6	—0.3
50	122.9	— 9.4	+5.4	173.5	—12.6	+2.2	244.7	—12.2	+2.6	300.2	—16.7	—1.9
58	132.5	— 3.4	—0.7	183.4	— 0.5	+2.2	243.6	+ 0.8	+3.5	[308.1	—11.7	—9.0]
94	129.8	— 2.1	+0.9	168.6	— 0.6	+2.4	247.3	— 2.8	+0.2	311.9	— 0.6	+2.4
98	174.0	+10.1	+2.1	167.0	+10.9	+2.9	246.7	+ 5.5	—2.5	320.8	+ 3.6	—4.4
	134.1		+1.10	179.9		+3.42	244.4		+0.91	311.5		—0.59

TABLE II.

LATITUDE OF THE LAKES.

Sta.	Name	M	1914 ⊙	1914 L	1914 L—M	1916 ⊙	1916 L	1916 L—M	1918 ⊙	1918 L	1918 L—M
23	Maeisia	—11°3	14°7	—14°8	—3°5	58°8	—10°1	+1°2	86°0	—11°5	—0°2
32	Phoenicis	—13.3	14.2	—14.3	—1.0	33.4	—13.1	+0.2	....	....	...
91	Ismenius	+45.5	24.0	+45.9	+0.4	59.3	+45.5	0.0	99.1	+45.2	—0.3
	Mean		17.6		—1.37	50.5		+0.47	92.6		—0.25

TABLE II—CONTINUED.

LATITUDE OF THE LAKES.

Sta.	1920 ⊙	1920 L	1920 L—M	1922 ⊙	1922 L	1922 L—M	1924 ⊙	1924 L	1924 L—M	1926 ⊙	1926 L	1926 L—M
23	130°2	—11°1	+0°2	182°6	—10°7	+0°6	247°9	—10°2	+1°1	326°0	—10°8	+0°5
32	120.0	— 9.0	+4.3	191.8	—11.8	+1.5	245.4	—15.3	—2.0	310.0	—16.3	—3.0
91	154.4	+44.3	—1.2	173.9	+47.8	+2.3	248.2	+44.2	—1.3	.....	....	...
	134.9		+1.10	182.8		+1.47	247.2		—0.73	318.0		—1.25

be left out will be explained presently. The first three columns give the numbers and names of the stations as recorded on my map (Report No. **36**), and their mean latitudes as given in *Harvard Annals,* **82**, No. 5, and Report No. **40**, based on my observations made at the apparitions of 1914, '16, '18, '20, '24, and '26, but omitting those made in 1922. This naturally makes some small differences in the third column. The remaining 21 columns in the two portions of the table are devoted to the seven apparitions. In 1926 only eight stations were used, as fully explained in Report No. **40**, on account of the obvious extended changes exhibited in the two omitted regions. Under each apparition the first column gives the mean solar longitude ☉ of the planet when the drawings were made, the second the mean latitude of the station at that apparition, as measured on the drawings and published in the *Harvard Annals* through the year 1922, and the third the difference between that latitude and the mean latitude for the six apparitions, as given in the third column of the table. The numbers in the first of these columns are identical with those given in Report No. **40**, the numbers in the third necessarily differ somewhat from them, but the resulting location of the pole is nearly identical.

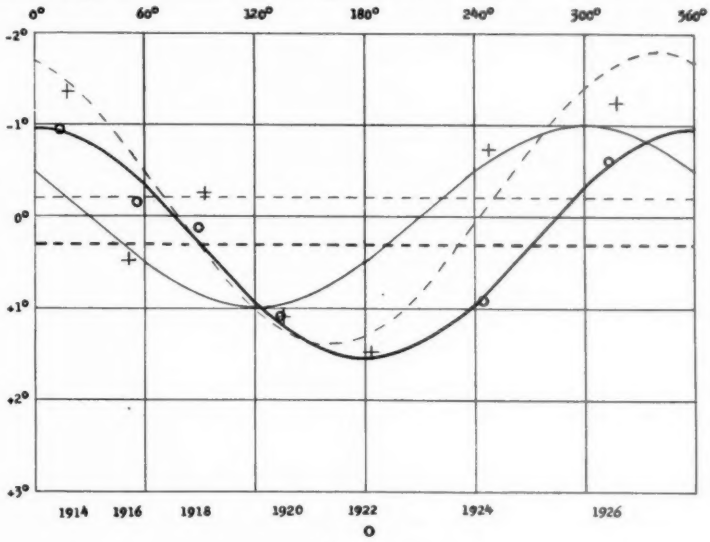


FIGURE 1.
APPARENT LATITUDE OF THE PLANET'S EQUATOR AT DIFFERENT SEASONS.

In Figure 1 the zero ordinate represents the mean position of the planet's equator. The ordinates L—M marked on the left indicate its apparent shift north or south as determined by the *American Ephemeris*, at different times of the planet's year, that is when the planet is in different

portions of its orbit. The abscissas give the solar longitudes ⊙ which are always 87°.5 to 88°.0 less than the heliocentric longitudes, and indicate the season, counting from the northern vernal equinox at 0°. The small circles give the deviation of the equator at each apparition. These are plotted, both abscissas and ordinates, from the last line of the table. The dates of the former are given at the bottom of the figure. Now if the *Ephemeris* position of the pole were correct, if the stations were stationary, and the observations without error, it is clear that the result would be a series of circles lying in a straight horizontal line coinciding with ordinate 0°. Instead, however, we find that one circle, that of 1922, lies far below the others, and that the remaining six lie closely along a sinusoid whose node is in longitude 90°, and whose amplitude is 1°.25. Their deviations from it are —0°.04, +0°.23, —0°.20, —0°.07, +0°.07, and —0°.06, mean deviation ±0°.11, or 4 miles. Trumpler suggested in his criticism of my earlier work that the reason that I obtained the large deviation from the *Ephemeris* indicated by the observations of 1922 was that my eye had changed, so as to make the center of the disk appear in a different position from that obtained in 1914 and 1918. If this were the case the change would presumably have continued, and not gone back in 1924 and 1926 to the sinusoid curve, and on the latter date to an ordinate lying between those of 1914 and 1916.

It is not believed now that the measures made in 1922 are in error, or are inferior in any respect to those made at the other six apparitions. I believe that an actual seasonal change of location of the vegetation upon the planet occurred. The following is my explanation of it. It is based in part on the measures of temperature made by Coblentz and Lampland at the Lowell Observatory during the summer of 1924, when the planet was exceptionally near the Earth. They showed that the temperatures of the maria were something like 20° F higher than the temperatures of the deserts in their immediate neighborhood, the exact reverse of what we find occurring upon our planet. (POPULAR ASTRONOMY, 1925, **33**, 371, and *Journal of the Franklin Institute*, 1925, June, July, page 67 of the Reprint.) The obvious explanation is an interesting confirmation of the view expressed long ago by the writer that the deserts are located at a higher elevation than the maria. Indeed there seems to be no other possible explanation of the difference. This difference is still another confirmation of our view that the planet possesses a very dense atmosphere,—an atmosphere much denser than that of our Earth, because while the differences of elevation upon it are small, yet the difference of temperature is marked, in spite of the small gravitational constant of the planet. About half-way between the northern summer solstice and the autumnal equinox the northern polar cap has nearly completely melted (Report No. **31**, Figure 1) and the water is travelling southerly, mostly through the planet's atmosphere. It is crossing the cold northern desert plateau, where much of it is doubtless absorbed, without producing much vegetation, save in the great depressions of Acidalium and the Syrtis. The remainder is dropping down to

fertilize the broad level plains of the southern maria lying just south of the equator. Vegetation soon begins to develop on their northern border, where the surface slopes up to the plateau, and which is more suited to vegetation than the colder more elevated regions still farther north.

This intermediate band of vegetation soon extends on an average to a distance of 70 miles farther north than it did before the water reached it. Most of the region thus covered lies well within the tropics, so that the temperature is controlled not by the seasons, but by the elevation. The moisture which at the northern autumnal equinox is so conspicuous as the southern polar cap is probably wholly derived from the southern maria, the moisture from the north never reaching it at all. In the mean time the slopes of the plateau, with the water supply exhausted, dry up, and by ten or twelve weeks after the autumnal equinox the vegetation on them has disappeared, leaving only that visible on the lower plains. At the opposite season of the Martian year, when the southern cap has melted, the moisture never reaches the deserts, but is absorbed by the maria themselves. This appears to me to be a simple and natural explanation of the temporary northerly advance of the maria as observed at the apparition of 1922. Owing to this advance, observations for the purpose of locating the planet's axis by the Apparitional method are not practicable for perhaps one-quarter of the planet's year. It thus appears that the Martian moisture, if the above explanation is correct, does not, as hitherto generally supposed, cross the whole planet from pole to pole, but at both seasons of its year has only to go half as far, to the southern maria and back again. It also appears that a large part of the northern water supply is wasted on the desert plateau, except for the comparatively small northern maria, which it will be noted, unlike the southern ones, turn blue instead of green when moistened. Some water is doubtless deposited on the elevated region north of Sabaeus, and on Elysium itself, on both of which regions clouds have been seen to form. The exceptionally narrow canals leading from them may then well carry the water down hill to Sabaeus, to the Syrtis major, and to the Charontis-Cerberus areas. (See map in Report No. **36**, 2.)

A simple trigonometrical solution based on the above mentioned curve, Figure 1, places the pole P^1 in 1925.0 in α 316°.18, δ +53°.66, see Figure 2. The *Ephemeris* position for the pole for 1925.0 is, as we have already seen, in 317°.63, +54°.57. Trumpler's position is in 315°.90, +54°.70, and Lowell's latest one in 316°.09, +54°.34. H. Struve's position, which was used for the ephemerides computed by Crommelin prior to those published by the *American Ephemeris* and was based exclusively on the orbits of the satellites, is shown for 1925 in 317°.43, +52°.72. Lowell's criticism of it is given in his *Bulletin* **56**. The mean position M^1 of Struve's, Lowell's, Trumpler's, and my locations, 316°.40, +53°.85, lies within 13′ of my position. The corresponding inclination of the axis of Mars to the pole of its orbit is 24°.1. If we

disregard Struve's position, and take the mean of Trumpler's, Lowell's, and my locations, we shall obtain the position M^3 in 316°.06, +54°.23, lying within 6′ of Lowell's position. The arrow indicates the direction, at an inclination to the meridian of 45°.2, and at a distance of 23°.6 of the pole of the planet's orbit.

If my explanation of the shift of the boundaries in 1922 is correct, there is certainly no reason to expect them to shift either continuously or irregularly at other times, but if any points on the planet do shift, we might think that those lakes situated on canals lying in an east and west direction should be as exempt as any markings could be from such latitudinal change. Indeed they would seem to be the ideal bodies to use in an investigation of this sort. The trouble with them is that there

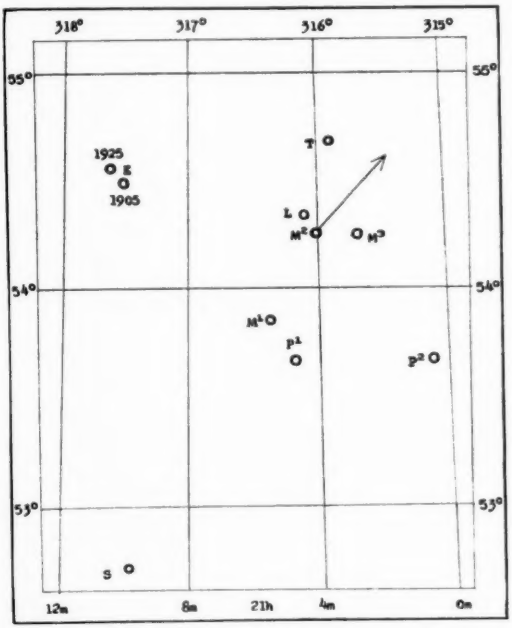


FIGURE 2.
LOCATION OF THE MARTIAN NORTH POLE.

are very few of them sufficiently conspicuous at all seasons of the year for our purpose. Only one, Maeisia, was drawn at all seven of the apparitions. Phoenicis and Ismenius were drawn at six of them, but none of the others at more than five, and often only one or two drawings were made each year. In Table II these three lakes have been treated in precisely the same manner as the ten points in Table I, with one exception, namely that having found that the lakes exhibited no northerly

irregular shift in 1922, we have therefore included this apparition in taking the means given in the third column. This causes the mean latitude of Maeisia to differ slightly from that given in Table I. Owing also to the fact that the positions of all three of the lakes are based on more measures than were used in the original survey, they differ somewhat, as do the positions of those points recorded in Table I, from the values given in the *Harvard Annals,* **82**, No. 5. In 1924 the number of observations of Maeisia, Phoenicis, and Ismenius with the Harvard University refractor was 4, 4, and 1. In 1926 with my reflector 1, 2, and 0. The dotted curve in Figure 1, node 70°, amplitude 1°.60, shows the result of this study, based on the crosses derived from the table. The computed pole 315°.12, +53°.67 is entered on the map, Figure 2, and marked P^2. Combining it with Lowell's and Trumpler's positions, we get the point M^3 in 315°.70, +54°.24. The measures on which this curve is based are so few, and the results so scattering that I do not put much confidence in its accuracy. Three conclusions may be drawn from it, however. It shows clearly that the marked irregular advance of the boundaries toward the north in 1922 does not occur in the case of the lakes. Secondly, it fully confirms the more accurate results derived from the boundaries P^1, and the measures of both Lowell and Trumpler in showing that the *Ephemeris* pole is seriously in error, and so much so that its position should be corrected at as early a date as possible. Thirdly, the latitude of P^2, confirming that of P^1, further contradicts Trumpler's northly position, which appears to me to be distinctly too far to the north. Indeed it is farther north than that of any other observer since Schiaparelli. The other two mean positions seem to me to be more probable than M^3.

The question now arises at once, is Struve's position reliable? We accept as accurate of course his theory and computations, but what of his data? The computation depends on the observed distances and directions of the satellites from the center of the planet, and it must be remembered that during the greater part of the observations, unlike the other outer planets of our system, Mars presents a very marked phase, the satellite's orbits lying nearly parallel to its equator, and therefore strongly inclined to its orbit and to the direction of its phase. Also that by irradiation the image extends out beyond the limb on one side, and owing to the refraction of the planet's atmosphere, to a usually greater, but somewhat uncertain extent beyond the terminator on the other. With a marked phase, variations of seeing must strongly affect the result, to say nothing of the varying brightness of the surface markings, and the frequent presence of cloud, perhaps half the time, either on the limb or terminator. I have already stated my criticism of Trumpler's results, but must say here that it does not seem plausible to me that he could be more than a degree in error. Whether Struve could be more than that we obviously have no means of judging.

At first I was inclined therefore to reject Struve's position altogether. The only possible use of knowing the position of the axis of

Mars more accurately than we do is to study the relative and absolute ***motions*** of the markings on its surface, and the location of the new ones that may from time to time appear. We want an axis that will give stationary results for stationary markings at different seasons, and that we shall now get approximately, as is shown for the first time by the present investigation, by using either of the three mean poles M^1, M^2, or M^3, as located from the work of the four Martian astronomers above mentioned. The heavy curve of Figure 1 indicates that we should get a still smaller shift throughout three-quarters of the orbit of Mars if we used P^1 for the pole. I have drawn in Figure 1 a similar sinusoid corresponding to the position of Trumpler's pole relatively to that of the *Ephemeris*. It is represented as a fine continuous line. It would indicate, if it was correct, that the average of my markings was anything but stationary in different years, that is at different seasons. On the other hand, in case most of the more important of the Martian markings are really stationary for the greater part of the year, then either his pole or my drawings are wrongly located, on the average by some 35 miles measured on the planet. But that is after all not very much, at a minimum distance of 35,000,000 miles. There is not any great error on either side with a total difference of 0".2. With Struve's pole every well-known point on the planet would have a marked annual (Martian) swing, averaging 70 miles, or a total range of 140 miles, in a direction nearly opposite to that indicated by Trumpler's pole. In my recent work in correcting the positions of my 100 known points on Mars, I rejected Struve's result, and adopted the middle mean position M^2. During the course of the present investigation, however, I decided to include Struve's position in this Report, for the purpose of obtaining an alternative location of the pole. Indeed those sidereal astronomers unfamiliar with Mars would probably consider his determination as the best of all. It has the advantage that it draws the pole somewhat to the south, partially neutralizing Trumpler's extreme position, and I now feel that M^1 is probably more likely to be correct than M^2. The distance between the two is 25′ or 15 miles,—about the width of an extremely narrow canal. Their mean value for 1925.0 is 316°.23, +54°.04. This position in any case cannot be far wrong.

It is perhaps a matter of interest to note that all the observers from Struve to Trumpler agree fairly well as to the direction of the Martian pole from the pole of its orbit, as measured in arc on the map at right angles to the line joining them, but that the important difference, about twice as great, consists in their values of the inclination of the axis of rotation, ranging from 25°.3, as given by Struve's position of the pole late in the last century, to 23°.2 as taken from Trumpler's position in 1924. The continued rapid decrease in the observed value of the inclination was noted by Lowell as far back as 1908, in *Bulletin* **33**, 201. As early determinations, he cites Herschel in 1781, 1783 as 28°.5, Schroeter in 1798 as 28°.0, Bessel in 1830 as 27°.3. Later observers such as Schiaparelli from 1879 to 1886 give the value 24°.7, Lohse 1884

to 1894 gives 24°.0, Struve in 1895, based on observations of the satellites extending back to 1877 gives 25°.2, Cerulli 1896 and 1898 gives 24°.8, and Lowell himself in 1911 from his later observations together with those of the fourteen years previous gives the value 23°.5. (*Bulletin*, **56**, 33.) For the period 1914 to 1926 the writer found the angle 24°.1. Finally, Trumpler in 1924, as above, gives the smallest value of all 23°.2. These results are plotted in Figure 3. In case the diminution were real, and should continue at its present rate, the axis of Mars would stand perpendicular to its orbit within 670 years. This is clearly impossible. No satisfying explanation has yet been found for the

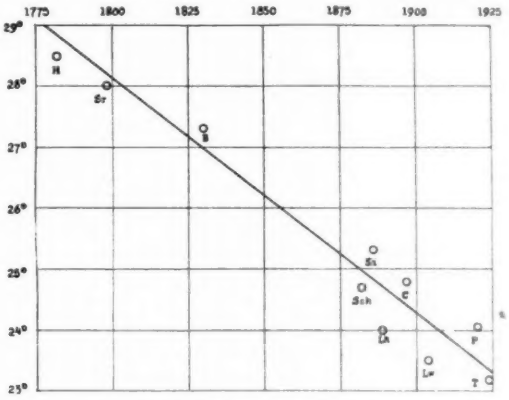


FIGURE 3.
THE INCLINATION OF THE AXIS OF MARS.

change. If real, there must be some reversing action. Polar Inversion, besides being apparently inadequate for such a rapid change, would act through the satellites as portions of a broken ring, only in the one direction of a diminution of the inclination of the axis to the axis of its orbit. (See "Why the Axes of the Planets are Inclined," POPULAR ASTRONOMY, 1917, **25**, 487.) If due merely to errors of observation, probably the most plausible explanation, the continuance of the diminution at a uniform rate through the centuries is certainly a matter of interest.

With regard to future investigations of the location of the pole, it is probable that still better results could be obtained by confining the observations to a few points situated as near as possible to the equator, so that they should never transit far from the center of the disk, nor near the limb. Possibly some of the promontories between the bays, although they would have no definite longitudes, might prove to be as satisfactory as the bays themselves, especially if the promontory lay in a nearly east and west direction. Their latitudes at the time of transit of the central meridian should be measured with a micrometer, and preferably with a

refracting telescope. While lakes situated on canals running east and west would doubtless be as useful as the boundaries, the chief difficulty to be overcome in observing them would undoubtedly be to get the micrometer webs near enough to them without extinguishing them visually. By the use of a Barlow lens to enlarge the image, while the thickness of the webs remained unchanged, it is possible that this difficulty might be in part overcome.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., JANUARY 15, 1930.

AMERICAN ASTRONOMICAL SOCIETY

REPORTS OF OBSERVATORIES
1928-1929

(Continued from page 228.)

OBSERVATORIES OF THE UNIVERSITY OF MICHIGAN

ANN ARBOR, MICHIGAN, AND BLOEMFONTEIN, SOUTH AFRICA

Instruction. Twenty-one courses in Astronomy were offered by the Observatory staff during the year, including a short and a longer course in Navigation. The total number of student registrations in Astronomy exclusive of the seventy-seven students in the shorter course in Navigation was 507. The Master's degree in Astronomy was awarded to Mr. John W. Corneal, Miss Angelyn B. Cunningham, and Mr. R. M. Petrie; the doctor's degree was conferred upon Miss M. Alberta Hawes, Mrs. Laura E. McLaughlin, and Miss Frances L. Seydel. In addition Mr. Walter J. Williams was actively engaged in work on his thesis for the doctor's degree.

A 15-inch pyrex reflector was nearing completion in the Observatory shop at the end of the year. The optical parts were received and accepted from J. W. Fecker.

Research. Observations with the one-prism spectrograph attached to the 37½-inch reflector were continued through the year. The principal observing program related to stars of Class B, with emission line spectra, north of —20° declination. Intensive observations were continued on a number of ϕ Persei spectrum variables. Other stars observed were β Persei, ϵ Aurigae, α Coronae Borealis, α Canum Venaticorum, W Cygni, 25 Serpentis, γ Bootis, and ζ Persei. A Moll self-registering spectrophotometer, loaned by the Physics Department, has been used extensively in the study of spectra of γ Lyrae, β Lyrae, P Cygni and other stars. Observations with this instrument showed that the combination of 37½-inch reflector and one-prism spectrograph produced no measurable selective absorption in the photographic region.

Spectral studies of β Persei, δ Cephei, HR 985, b_2 Cygni, P Cygni, 25 Orionis, κ Draconis, υ Sagittarii, ζ Tauri, α Lyrae, γ Lyrae, β Lyrae,

ϵ Aurigae, and other objects were also carried on during the year.

A further program of stellar spectroscopic work was completed with the measurement and reduction of numerous spectrograms of twenty intrinsically brighter stars for the study of changes in wave-length with spectral class over the spectral range of the brighter Cepheids. This was done to aid in the interpretation of wave-length variations synchronous with the light changes of Cepheid variables and to classify accurately the spectra of the stars so studied.

Those engaged in the spectroscopic observations and investigations were the following: R. H. Curtiss, W. C. Rufus, D. B. McLaughlin, A. D. Maxwell, H. F. Schiefer, W. J. Williams, Hazel M. Losh, M. Alberta Hawes, Laura E. McLaughlin, Frances L. Seydel, A. L. Bunting, Howard Rufus, and M. B. Stephenson.

The 12-inch refractor, with a Zöllner photometer attached, was employed throughout the year by D. B. McLaughlin in the measurement of variable stars. Most of the objects under observation were eclipsing binaries, chosen mainly from among those of especially long period and late spectral class.

Numerous observations have been obtained of the eclipsing variables RS Arietis, ϵ Aurigae, RZ Cancri, RT Leonis, RW Coronae, TT Herculis, WZ Ophiuchi, AK Herculis, W Serpentis, W Scuti, AD Herculis, and S Equulei. Sequences of comparison stars for BR Cygni and AQ Pegasi have been measured. A beginning has been made on RX and RY Geminorum. X Trianguli has been added to the program to serve as a basis of comparison with the measures by Dugan. Other stars observed are RV Tauri, TU Aurigae, RU Coronae, TW Pegasi, and V Lacertae. The total number of readings on variable stars obtained since the last report is 10,042, making a total of 22,652 since the program was begun. Estimates by the Argelander method have been made of β Lyrae, δ Cephei, η Aquilae, S Sagittae, R Scuti, and W Cygni.

Seismology. The Bosch-Omori and Wiechert horizontal seismographs have registered continuously throughout the year. Eighty earthquakes were recorded and studied between July 1, 1928, and July 1, 1929. Eighteen of these with more clearly defined phases were reported by wire to *Science Service*, Washington, D. C., and to the Jesuit Seismological Association of St. Louis, Missouri. These records have been interpreted by R. H. Curtiss and Miss Mary E. Lindsey.

Meteorology. Standard morning and evening observations for the United States Weather Bureau have been continued through the year.

Contributions. R. H. Curtiss and W. C. Rufus were engaged during the year in the preparation of material for the *Handbuch der Astrophysik*. Various papers of members of the staff were published in current periodicals or presented before scientific societies.

Staff. The full time staff of the Observatories of the University of Michigan included Professor R. H. Curtiss, Director; Associate Professor R. A. Rossiter (in immediate charge in Bloemfontein); Assistant

Professors W. C. Rufus and D. B. McLaughlin; Dr. A. D. Maxwell, Mr. W. J. Williams, and Dr. Hazel M. Losh; Astronomers M. K. Jessup (in Bloemfontein) and H. F. Donner (in Bloemfontein); Miss Mary E. Lindsey, secretary and seismological assistant; Mr. H. J. Colliau, superintendent of instrument construction; and Mr. Newell E. Smock, instrument maker. Five part time assistants in Astronomy, Meteorology, and Seismology were associated with the staff.

Judge Henry S. Hulbert, Mr. Francis C. McMath, and Mr. Robert R. McMath were appointed honorary curators of astronomical observations by action of the Board of Regents on June 14, 1929. The counsel and coöperation of these prominent citizens of Detroit have long been of greatest value to this Observatory. Their active association in the work of this institution and their participation in its researches are some of the most encouraging prospects for the future.

Professor E. A. Milne of Oxford University was a visiting member of the Summer Session staff of 1929.

The Lamont-Hussey Observatory. The resources of this observatory, which is supported entirely by the Honorable Mr. R. P. Lamont, Secretary of Commerce, have been devoted to the study of southern double stars. The systematic search for new doubles had yielded a total of 1533 discoveries at the end of the first year's work, on May 8, 1929. In the same time 4628 double-star measures had been made. The number of nights suitable for searching and measuring, whether wholly or in part, was 241; and the number of nights on which the telescope was actually used was 310—a most remarkable record. The number of double stars discovered at last advices (August 20, 1929) was 1980.

Visitors. Eleven hundred and ninety-four visitors were received at the University Observatory and Angell Hall Laboratory during the year. Of these 733 saw some celestial object through a telescope. During the first year at the Lamont-Hussey Observatory 2606 visitors were received of whom 1992 looked through a telescope. The total of visitors received at the two institutions was, therefore, 3800 for the year.

R. H. Curtiss, *Director.*

MOUNT WILSON OBSERVATORY

Carnegie Institution of Washington

Pasadena, California

Solar Research. In continuation of the regular program of observations direct photographs of the sun and spectroheliograms have been made on 312 days. Disturbed regions have been specially studied with the spectroheliograph. Rapidly moving prominences and filaments have been observed visually and measured by Hale with the spectrohelioscope. The number of sun-spot groups observed at Mount Wilson decreased from 424 in 1927 to 362 in 1928. At the same time, the mean latitude decreased from 15°.5 to 13°.6. The maximum, which seems, therefore,

definitely to have passed, appears to have been of the broad rounded type, similar to that of 1905 and less conspicuous than that of 1917. Magnetic fields in sun-spots were measured on 305 days in 1928. Only 8 of 310 groups were irregular in polarity. Nicholson has compared different types of solar disturbances with variations in terrestrial magnetism. Hale has developed plans for coöperative observation of the sun with the spectrohelioscope at points distributed around the earth, and four spectrohelioscopes constructed in our shops have been delivered to participating observatories.

Babcock has continued his study of the infra-red solar spectrum and has measured over 350 lines between λ 9867 and λ 11,634 with a precision which admits identification of many of these lines. Potassium, magnesium, calcium, and other light elements are represented. Atomic carbon seems to have an important multiplet near λ 10,800. Babcock has now measured about 2500 solar lines to the red of the limit of Rowland's Table at λ 7330.

The analysis of Babcock's measures of the bands of atmospheric oxygen led Giauque and Johnston last year to the discovery of an oxygen isotope of mass 18. Babcock has now found two additional bands, one associated with the O^{16}-O^{18} molecule, the other, according to Giauque and Johnston, originating in an isotope of mass 17. The method of different air paths indicates that this relative abundance of the three isotopes O^{16}, O^{17}, O^{18} is of the order of 10,000 : 1 : 8.

St. John has continued measurements of the rotation period of the sun and of the center-limb displacements of selected groups of lines. He has commenced a series of micro-photometric measurements of the intensities and contours of groups of multiplets in the solar spectrum. Two spectrophotometric investigations have been carried on by Dr. Unsöld. In the first based upon the contours of the H and K lines he derives formulae for the intensity of the emergent light as a function of the temperature and the coefficients of scattering and absorption in the solar atmosphere and explains the origin of the central K3 line. In the second investigation based on lines of Ca^+ and Ba^+ he finds that Boltzmann's relation gives the correct proportion of highly excited atoms up to excitation potentials of 1.7 volts. He concludes that the deviations from the relation in stellar atmospheres is due to an excess of such atoms rather than a deficiency of those in a low state of excitation.

Dr. Russell has found in the course of an extensive investigation of the solar atmosphere that elements with excitation potentials for the strongest lines of less than about 5 volts show lines in the spectrum. About 50 per cent of the atoms with an ionization potential of 8.3 volts are ionized. Tables giving the relative abundance of 56 elements and 5 compounds show that six elements, calcium, iron, magnesium, potassium, silicon, and sodium contribute 95 per cent of the whole mass of the solar atmosphere. By volume hydrogen contributes 60 parts, helium 2, oxygen 2, metallic vapors 1, and free electrons 0.8.

Pettit has completed a 5-year series of measurements of the ultra-

violet radiation of the sun. The highest monthly average of the ratio at $\lambda 0.32\mu$ to $\lambda 0.5\mu$ was 1.57 for November, 1925, and the lowest, 1.12, for September, 1928. The general trend of the monthly averages follows the curve of sun-spot numbers. Pettit has also measured the amount of sky radiation at $\lambda 0.32\mu$ in Pasadena, and has photographed lines in the solar spectrum slightly to the violet of $\lambda 0.29\mu$.

Lunar Observations. Lunar observations have included direct photography and measurements of radiation. Pettit and Nicholson have investigated the law of distribution of heat across the disk of the full moon, and have found the radiometric magnitude of the sub-polar point to be +1.74 per square second of arc, corresponding to a temperature of 370° K. Observations of the amount of conducted heat were made at the lunar eclipses of June 14, 1927, and November 26, 1928. The value of 0.1 cal. cm^{-2} min^{-1} obtained at the former eclipse was used by Dr. Epstein who found that it corresponds most closely to materials like volcanic ash or pumice.

Investigations on Nebulae. Pease and Dr. Duncan have obtained numerous photographs of nebulae some of which show additional novae and variable stars. Hubble has completed his investigations of the distances and dimensions of the three largest extra-galactic nebulae of the northern sky, and is studying a selected list of objects which may provide material for the statistical treatment of more distant nebulae. His systematic survey of small nebulae is about 90 per cent completed.

Measurements by van Maanen of N.G.C. 4051, a nebula with an apparently definite spiral structure, give an annual proper motion, based on an interval of 11 years, of $+0''.005 \pm 0''.001$ in right ascension, and $+0''.017 \pm 0''.0015$ in declination. The spectrum is of the planetary nebula type, and the absolute magnitude derived by van Maanen is in good agreement with the values previously obtained for the central stars of planetaries.

The following apparent radial velocities for extra-galactic nebulae have been obtained by Humason and Pease: Three nebulae in the Coma Berenices cluster, +4700, +7300, +7800 km/sec; one nebula in the Pegasus cluster, +3800; N.G.C. 3227, 4051, and 6359, which are not members of clusters, +1150, +650, and +2800 km/sec. In general these results tend to confirm Hubble's linear relationship of an increase of about 500 km/sec in radial velocity for each 1,000,000 parsecs in distance, and their application to the space-time structure of the world is a subject of great interest. A determination by Hubble of the distance of the Coma Berenices cluster of 50,000,000 light-years is of importance in this connection.

Miscellaneous Stellar Investigations. Among stars of exceptionally large parallax van Maanen has obtained values of $+0''.213$ for Wolf 562, and $+0''.084$ for Ross 136. The absolute magnitude of Ross 136 is +14.2. Numerous first-epoch photographs have been obtained by van Maanen for the proper motions of Cepheid variables, and values

derived for 5 planetary nebulae indicate that their distances are of the same order as those of the comparison stars. About 34,000 stars in 21 fields of the Selected Areas with magnitudes between 10 and 20 have been examined for proper motion, and 59 stars have been found with values between 0″.049 and 0″.451 annually.

The Mount Wilson Catalogue of the Selected Areas containing the photographic magnitudes of 67,941 stars is now in press. Seares and Miss Joyner are now reducing the photovisual magnitudes in 42 of the Selected Areas, determining the scale independently for each area, and making intercomparisons with the pole and adjacent areas. The color-indices so far obtained from exposure-ratio photographs are in good agreement with those derived from the magnitudes of the stars.

The 20-foot stellar interferometer has been used by Pease for measurements of a few stars. The diameter of o Ceti at the maximum of 1928 was 0″.047 as compared with the previous value of 0″.056.

Successful measurements have been obtained by Dr. Abbot of the spectral energy distribution for 18 stars and the planets Mars and Jupiter. The results, obtained with a special fused-quartz radiometer, show a probable error of about 10 per cent of the deflection measured.

Stellar Spectroscopy. About 1500 spectrograms have been obtained during the year. Most of these were secured with the Cassegrain spectrographs, but instruments ranging from the 15-foot coudé spectrograph to the short focus spectrograph used for spectra of nebulae were also employed. A catalogue containing the radial velocities of 741 stars measured during recent years has been completed by Adams, Joy, Sanford, and Strömberg. Small systematic corrections amounting at maximum to 0.9 km/sec have been applied, based upon an extensive comparison with results from the Lick Observatory. The catalogue contains about 60 stars with velocities exceeding 50 km/sec all of which show very prominently the asymmetry of stellar motions.

The velocity-curves of the spectroscopic binaries Lalande 17480 and Boss 4865 have been determined by Sanford, and values have been obtained for α Orionis and the Cepheid variable W Geminorum. Joy has investigated the velocity-curves of many of the fainter Cepheids, short-period variables and stars of the RV Tauri type. Results are nearly complete for W Serpentis, W Virginis, U Sagittae, RS Canum Venaticorum, and RT Lacertae. A special study has been made by Merrill and Joy of the variable R Virginis with a period of 145.4 days. Changes of light and spectral type have been correlated with the velocities given by the absorption lines and the quite different values given by the bright hydrogen lines.

More than 160 bright lines have been measured by Merrill and Miss Burwell in the spectrum of the Be-type star B.D. +11°4673. Nearly all of these vary in intensity and position. First, second and third-stage ionization is represented among them, and forbidden lines of Fe II and N II, including some of the nebular lines, are well marked.

Further stellar spectroscopic investigations have included the classifi-

cation of faint stars in the Selected Areas by Humanson, and of the fainter components of visual binaries by Leonard; observations of infra-red spectra and of the detached lines of Ca II and Na I by Merrill; and observations and measurements of high-dispersion spectra of bright stars by Adams, Dunham, and Christie.

Spectroscopic determinations of absolute magnitude and parallax have been continued and results are partially completed for nearly 4000 stars. Additional lines are being included in the measurements, and the entire material is being reduced to a homogeneous system. A special study of the spectral types and provisional absolute magnitudes of 80 Cepheid variables shows a close correlation between magnitude and type. The resulting values are about one magnitude fainter than those given by the period-luminosity relationship.

Strömberg has developed and applied to the giant M-type stars a method for obtaining the distribution in absolute magnitude without any assumption as to the analytical form of the distribution function. The results indicate two separate groups with mean absolute magnitudes of about 0 and —2.

Laboratory Investigations. King has engaged in a general survey of the spectra of europium, gadolinium, terbium, disprosium, and holmium in the region λ3850 - λ4700. The electric furnace in conjunction with the arc and spark has been used for temperature classification and for separation of the lines of the neutral and ionized atoms of the rare earths. Of the 10 rare earths thus far studied, those of odd atomic number have lines with hyperfine structure, while the lines of even number are sharp. Wave-lengths have been measured for 800 lines of neodymium.

A faint band near the Swan band at λ4737 led King to suspect the presence of a carbon isotope. Tests made in coöperation with Dr. Birge confirmed its existence and showed its mass to be 13. The investigation also showed that the Swan bands are produced by diatomic carbon.

With fused quartz vacuum tubes of 1 mm bore Anderson has studied discharges as high as 3,000,000 amperes per sq. cm. With discharges above 300,000 amperes quartz evaporates from the walls of the tube and is dissociated into silicon and oxygen. Under these conditions the tube shows in the capillary the low-temperature absorption lines of silicon, and elsewhere, emission lines of the first four stages of ionization. The experiments indicate that a layer of the gas 1 mm thick, at a pressure of 0.1 to 0.2 mm and sufficiently ionized to carry a current of 100,000 amperes per sq. cm. is opaque.

For all metals thus far studied except tungsten the expanding mass of gas produced by a wire explosion shows many jets projecting perpendicularly to the direction of the wire. Anderson's experiments connect this phenomenon with the resistance of the gas, which will be high unless the temperature of vaporization is so high that abundant ionization is present. For tungsten the boiling point is high; the ionization affords a low-resistance path and the mass of expanding gas is smooth.

For other metals the discharge approaches the disruptive conditions of the spark, the projecting jets corresponding to the striations of the spark discharge.

Babcock has found that the commercial neon lamp may be used as a source of comparison spectra for argon, helium, and hydrogen, which occur as impurities in the neon. The conditions differ considerably in the 110 and 220 volt lamps.

Pettit has determined the voltage sensibility curves for photoelectric cells, both gas filled and vacuum, coated with sodium, potassium, and caesium. He finds that the galvanometer deflections with a rotating sector placed in front of a photoelectric cell are slightly less than those calculated from the aperture of the sector. The speed of the sector seems to have no important effect.

Smith's study of radiometers indicates that the best form is of the shielded-vane type, with vanes of mica, suspended in an atmosphere of neon. Mica vanes 1 wave-length thick seem to be both lighter and stronger than insects' wings. Calcium is the best substance hitherto tried for the mirror. The sensitivity of the best instrument thus far made is 4 times that recently used by Abbot for measurement of stellar radiation.

Anderson and Mr. R. W. Porter have investigated Ronchi's method of optical testing and find it to be fully as sensitive as Foucault's method, and more convenient, because it can be used in a lighted room.

The fidelity of the registering microphotometer has been shown by Pettit, who has compared a registered curve with one computed from counts of silver grains on a photomicrograph of the original negative. The agreement is excellent.

Velocity of Light and Michelson-Morley Experiment. Difficult atmospheric conditions have made it impossible to extend Dr. Michelson's measures of the velocity of light to include stations on Mount San Jacinto (82 miles from Mount Wilson) or on Santiago Peak (50 miles distant). To check the measures made between Mount Wilson and Mount San Antonio (22 miles) it is now proposed to use a short base line of 1 mile. The beam of light will be reflected back and forth several times in a line of pipe from which the air has been exhausted to a low pressure. A section of pipe 1100 feet long is now under construction, and if preliminary measures with this length are as successful as anticipated, the line will be extended to the full mile.

A third series of measures with the large interferometer made by Pease and Pearson under the direction of Professor Michelson confirm the results of the first two series. With the instrument mounted in a room of nearly constant temperature and a light path of 85 feet, a displacement corresponding to an ether drift as large as 6 km/sec should have been revealed by the measures. No appreciable displacement was observed.

W. S. Adams, *Director.*

UNITED STATES NAVAL OBSERVATORY

WASHINGTON, D. C.

Changes in the staff. CAPTAIN H. G. S. WALLACE, U.S.N., appointed Assistant Superintendent. Nautical Branch: COMMANDER G. W. KENYON, U.S.N., appointed Equipage Officer; COMMANDER S. F. HEIM, U.S.N., appointed Maintenance Officer; LIEUTENANT-COMMANDER R. DUDLEY, U.S.N., appointed Compass Officer. Transferred: CAPTAIN A. H. RICE, U.S.N., COMMANDER I. H. MAYFIELD, U.S.N., COMMANDER W. O. WALLACE, U.S.N., LIEUTENANT-COMMANDER D. B. DOWNER, U.S.N. Astronomical Branch: Retirements: CAPTAIN W. S. EICHELBERGER and COMMANDER ASAPH HALL, Corps of Professors of Mathematics, U.S.N. JUNIOR ASTRONOMER I. A. KITTELL appointed. JUNIOR ASTRONOMER ARTA H. HADFIELD, resigned. Director of the *American Ephemeris* (successor), JAMES ROBERTSON. Head of the Equatorial Division (successor), HARRY E. BURTON.

Navigation. A post-graduate course of study in compass installation and nautical instrument design has been established for naval officers.

Time. Official time for the United States is being furnished daily through the naval radio stations at Arlington, Annapolis, San Diego, Key West, Great Lakes, New Orleans, Eureka, and Astoria. An appropriation is expected for beginning a replacement of the standard clocks by others of higher precision. Meanwhile the developments in regard to quartz crystal oscillators are being closely followed, with a view to taking advantage of assured results to improve the accuracy of the time service. All pertinent data as to the time service can be obtained on application to the superintendent.

Ephemeris Department. A supplement to the *American Nautical Almanac* is being issued under the caption "Lunar Ephemeris for Aviators." It is designed to facilitate the reduction of simultaneous observations of the sun and moon to determine position.

The new zodiacal catalogue, in course of preparation, will contain all the stars in the Harvard Photometry of magnitude 7.0 or brighter that were not included in Hedrick's Catalogue or Gill's List. Modern positions of these 345 stars will be furnished by the Cape Observatory and by this Observatory.

Work on the investigation of the orbits of Saturn's satellites has been confined to the comparison of Barnard's observations 1917-1922 with theory.

Meridian Astronomy. Of the 72,330 observations secured with the 9-inch transit circle during the period 1913-1926, the apparent star places are all reduced. The mean places are reduced and entered on the card catalogue to 1923. These observations are being discussed for systematic corrections. Day corrections have been determined and applied to the day work. The observations of the moon have been discussed for corrections to the tables.

The 3500 zodiacal stars scheduled for four observations each with the 6-inch transit circle during last year and this were half completed somewhat in advance of schedule. The remainder of the observations is proceeding after an interchange of micrometer and objective and a

rotation of the circle on its axis by 43° 28′. During the year, 11,921 observations were made with this instrument.

The declination observations with the altazimuth have continued with 1962 observations for the year.

With the photographic reflex zenith tube 1867 observations were secured for the determination of variation of latitude during the year.

Equatorials. The 26-inch and 12-inch equatorials have been used in the observation of occultations, Jupiter satellite eclipses, and satellite, asteroid, and comet positions. A Hartmann test of the 26-inch objective yielded a "technical constant" of 0.62, which, though "good" in the Hartmann classification, is only average by comparison with other glasses. A more rigid test of the objective is planned using the visual rays, for which it is corrected, by employing isochromatic photographic plates with a "minus-blue" color filter.

Astrographic Work. The 10-inch photographic telescope has been placed in operation after a thorough overhaul. Photographs of the sun were secured on 297 days with the photoheliograph, spots or groups being present on all but one of the plates. Current solar observations are published monthly in the official *Weather Review*, issued by the Department of Agriculture, Harvard Laboratory, Yerkes, and Mount Wilson supplying dates missed by the Naval Observatory.

Measurable progress has been made in the plans for amplifying the astrographic work of the Naval Observatory, as well as for modernizing in certain respects the present astronomical equipment.

Publications. Volume XII, *Naval Observatory Publications*, second series, is about to be distributed. It will contain the equatorial observations for the period 1908-1926, the photographic equatorial observations for the period 1912-1927, the photoheliograph observations for the period 1917-1927, and an appendix setting forth the results of the observations made at San Diego and Washington during the world longitude operation of 1926.

The *American Ephemeris* for 1931 has been printed; that for 1932 is practically complete. The *American Nautical Almanac* for 1930 and 1931 are both completed. The *Lunar Ephemeris for Aviators* for the period September 1-December 31, 1929, has been distributed. The issue for the period January 1-April 30, 1930, will be ready shortly.

Miscellaneous. The Naval Observatory sponsored a gravity measurement expedition aboard the United States submarine S-21 in the fall of 1928, in which there participated Dr. F. A. Vening Meinesz, of the Geodetic Commission of the Netherlands; Dr. F. E. Wright, of the Carnegie Institution of Washington; and Mr. E. B. Collins, of the Hydrographic Office of the Navy. The expedition occupied 56 days and covered approximately 7,000 miles along the Atlantic continental shelf and in West Indian and Gulf of Mexico waters. A total of 49 new gravity stations, of which 46 were open-sea stations, were established. A definitive report on the results of the expedition will be issued as soon

as practicable.

The Naval Observatory Eclipse Expedition of 1929, in charge of Commander C. H. J. Keppler, U.S.N., and composed of Professor William A. Cogshall, of the University of Indiana, the leading scientist of the expedition; of Mrs. Cogshall; of Astronomer Paul Sollenberger, of the Naval Observatory staff; and of Lieut. H. C. Kellers, Medical Corps, U. S. Navy, was successful in obtaining 56 negatives of the total solar eclipse of May 9, 1929, at Iloilo, Philippine Islands. The report on the eclipse observations is in course of preparation.

C. S. Freeman, Captain U.S.N., *Superintendent.*

PRINCETON UNIVERSITY OBSERVATORY

Princeton, New Jersey

Mr. Russell's publications include a quantitative discussion of the effectiveness of meteoric matter in producing diffuse absorption bands in stellar spectra, this paper giving a general treatment of the evaporation of meteoric material close to stars, (*Ap. J.*, **69**, 49, 1929); a catalogue of dynamical parallaxes of 1777 double stars, in collaboration with Miss Moore (*A. J.*, **39**, 165, 1929); a paper on the arc spectrum of nickel (*Phys. Rev.*, **34**, 821, 1929); and a joint paper with Dr. W. F. Meggers on the analysis of the arc and spark spectra of yttrium (*Bur. Stand. J. R.*, **2**, 733, 1929). Other papers, among them one on the composition of the sun's atmosphere (*Ap. J.*, **70**, 11, 1929), are summarized in the Mt. Wilson report.

Mr. Dugan continued his photometric observation of the eclipsing variables SX Cassiopeiae, VW Cephei, TY Pegasi, RT Persei and concluded his observation of Y Cygni and W Ursae Minoris. The total number of measures (to Jan., 1929) was 10,272. The results of the discussion of the observations of WW Aurigae were published (*P.A.S.P.*, **41**, 176, 1929). The card catalogue of bibliography of eclipsing variables has been kept up to date by Mr. Dugan and Miss Young.

Mr. Stewart, with the collaboration of Mr. S. A. Korff, conducted experiments on the relation of scattering to true absorption in sodium vapor, which indicate that scattering predominates only near the edges of the dark lines (Abstract, *P. A.*, **37**, 390, 1929; full discussion in the *Astrophysical Journal*). He and Mr. Korff continued experimental investigations of refraction and opacity of the alkali vapors (*Phys. Rev.*, **32**, 676, 1928; **33**, 584, 1929; **34**, 457, 1929). Miss Moore made a brief study of the relation between line intensity and anomolous dispersion, employing Dr. A. S. King's observations (*P.A.*, **37**, 273, 1929). Mr. Stewart also has published abstracts and papers in which the conceptual structure of thermodynamics is taken as a model for mechanics and for other special fields in physics (*Phys. Rev.*, **33**, 637, 641, 1073, 1929; **34**, 1052, 1929). Mr. R. F. Arnott, of Upper Montclair, N. J., assembled a camera for taking astronomical moving pictures, and in collaboration with Mr. Stewart, and with Messrs. A. L. Bennett and E. G. F. Arnott,

graduate students, a motion picture of sunrise on the lunar crater Copernicus was taken in May, with the 23-inch telescope (*Nature*, **124**, 56, 1929).

The doctoral dissertation of Mr. Theodore Dunham, Jr., "The Spectrum of Alpha Persei," was prepared for publication as *P.U.O. Contribution*, No. 9.

The Observatory of Instruction was given a much needed remodeling and renovating, with the provision of office space, store rooms, and workshop. New running gear for the dome of the 9½-inch telescope was installed, and better class-room facilities arranged.

Mr. C. O. Lampland, of the Lowell Observatory, was in residence at Princeton during the second semester as Exchange Professor, while Mr. Dugan was at Flagstaff. Mr. Russell went on sabbatical leave in June. Miss Charlotte E. Moore left at the end of the year to take up graduate work at the University of California. Mr. A. L. Bennett entered the department as a graduate student.

R. S. Dugan, *Acting Director.*

[To be continued.]

THE TRANS-NEPTUNIAN PLANET

By WILLIAM H. PICKERING.

As soon as Neptune had been discovered by Leverrier and Adams it naturally occurred to many astronomers that other planets beyond it might be found by the same method. The difficulty was that the remaining unexplained perturbations of Uranus were so small that they could hardly be distinguished from accidental errors, and that for many years Neptune exhibited no unexplained perturbations at all. Todd was perhaps the first astronomer who undertook the rather discouraging investigation of residuals, and actually searched for the planet with a large telescope. He was followed by Lau, See, and Gaillot. At practically the same time as the latter, in 1909 the writer took it up. We were both unfortunately obliged to refer back to Leverrier's orbit of Uranus, since Newcomb, whose elements were far better, was retired for age of Naval Officers by the American Government before he could prepare a list of the early deviations of the planet. The writer's publication was in the *Harvard Annals*, **61**, 113, and a copy of the latter portion of his curve as given in Figure 24 was printed on a somewhat different scale, and with Gaillot's deviations added, in Popular Astronomy, 1928, **36**, 152. This Figure is reprinted here as Figure 1. The upper curve is a plot of Leverrier's deviations represented as ordinates, with those of Greenwich added to his orbit for the later years. The object of the two later investigators was to reduce these deviations as far as possible to a straight horizontal line, or in other words more accurately expressed

to reduce the apparent unexplained residuals to a minimum. The constants employed in this investigation were selected by the writer by graphical methods, and by Gaillot by the usual analytical form of treatment. After the graphical selection was made, all the deviations could be computed in a very simple manner with a great saving of time. The

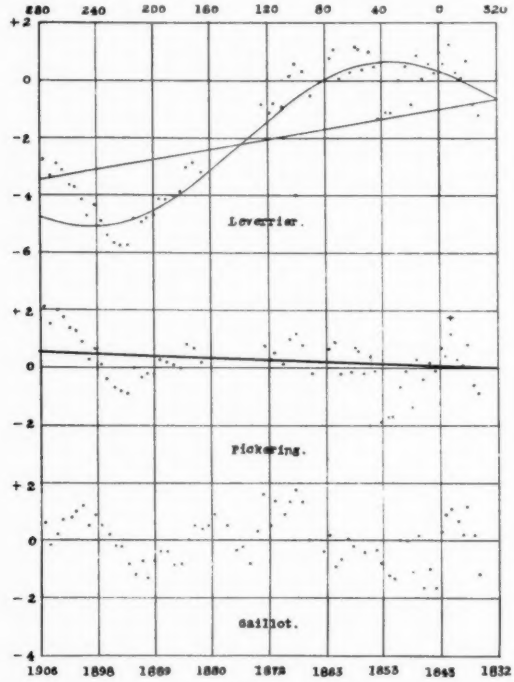


FIGURE 1.
ACCEPTED AND REVISED ORBITS OF URANUS PERTURBED BY *O*.

graphical method which I have fully explained in the above named publications, but perhaps best in POPULAR ASTRONOMY and in *Harvard Annals*, **82**, 56, has the two additional advantages that with it there is a smaller likelihood of accidental computational errors, and that given the facts it is certain to give a more accurate orbit. In the selection of the constants the writer believes from the flatness of his curve, and its smaller computed average deviation, that he was the more successful.

Lowell, however, preferred Gaillot's results, and founded his investigation, published in 1915, and giving an elliptical orbit, on the theory of a large perturbation occurring in or near 1868, and modifying it by the remaining smaller deviations of the curve. This large perturbation showed a total deviation according to Gaillot of about 3″, while that

produced on Uranus by Neptune, and by means of which its location in the heavens was predicted, amounted to about 90″. The writer used this same perturbation, which he called 1865.5, and an earlier one not observed, but which he believed for reasons there given, to have occurred in 1757. Two perturbations of course gave him only a circular orbit, but he foresaw and stated that a perturbation of Neptune due to the unknown planet, which he called *O*, would shortly occur, and when its maximum had been determined an accurate third position could be located, giving a much more satisfactory elliptical orbit. He did not believe that the perturbation of 1865, even when combined with the rest of the orbit, could lead to a satisfactory result.

The expected perturbation of Neptune shortly arrived, and by 1919 the writer believed it had so far developed that it was safe to say that its maximum had been passed in 1910. Based on that date and the two previous ones based on similar dates for Uranus, an elliptical orbit was computed and published in *Harvard Annals*, **82**, 49. This orbit we shall call O^1. It differed entirely from Lowell's, and would in general locate the planet in an entirely different part of the sky, but by a curious coincidence at the time that the planet was publicly announced in 1930.2 the two positions very closely agreed. Lowell's orbit placed the planet in longitude 102°.2, the writer's placed it in longitude 102°.8, or about a Moon's diameter distant, and the planet was actually found in longitude 107°.5. For 1920.0 for which date the writer's orbit was computed, and at which time it was published, Lowell's orbit gave the planet a longitude of 90°, while the writer's made it 97°.8. For 1914.5, the date selected by Lowell, his longitude was 84°.0, and the writer's 95°.4, a difference between the two orbits of 11°.4. Lowell gives also another possible longitude for this date of 262°.8, and says "between the elements of the two, there is not much to choose, all agreeing pretty well with one another."

The problem of the location of Neptune by Leverrier and Adams was in one respect more simple than the same problem now appeared. They had a large perturbation of Uranus of about 90″ as we have just seen, and owing to the large mass and proximity of Neptune, had only one perturbation of that size to deal with. Therefore what they had to do was simply to locate that planet. Similarly Lowell, who employed their method, also believed that there was only one important perturbation of Uranus, that of 1865. When using the graphical method of solution, however, we at once find that a new difficulty arises,—for instead of one perturbation of Uranus, we discover that there are at least three other possible ones. There is, moreover, one very marked perturbation of Neptune, amounting to fully 3″, and perhaps to 4″, which is the most marked and certain of all. Since we cannot for theoretical reasons use all four of these perturbations, the problem very definitely arises which shall we use and which reject with the particular planet found at Flagstaff? The successive columns in Table I give the date on which the known planet, Uranus or Neptune, showed its maximum perturbation,

also the date of announcement of *O*, their differences, the planet perturbed, or in the last case *O* itself, the longitude of the perturbed planet on the date in question, the computed correction to this longitude to give

TABLE I.

PERTURBATIONS OF THE PLANETS URANUS AND NEPTUNE.

Year	Diff.	Planet	Long.	Corr.	Long. *O*	Diff.
1757.1		U	351°	—11°.4	339°.6	
	84.6					367°.4
1841.7		U	353.7	— 6.7	347.0	
	23.8					83.1
1865.5		U	90.0	—19.9	70.1	
	36.9					13.7
1902.4		N	91.0	— 7.2	83.8	
	27.8					23.7
1930.2		*O*	—	—	107.5	

the longitude of *O*, its resulting longitude, and the differences. The corrections given were those that were actually employed in the computation.

Now it is certain that within the past hundred years *O* must have been passed by Uranus, given the present longitude of that planet. The first and third perturbations of Uranus are the most obvious ones that will combine to make a plausible orbit with the perturbation of Neptune. The first is dependent on the third, as explained in the *Harvard Annals* above mentioned, but the third, which was used by both Lowell and myself, is very much open to doubt, as was explained fully in POPULAR ASTRONOMY, 1928, **36**, 353. One trouble with it is, that it is not the proper shape for a perturbation, being distinctly too long, see the second curve of Figure 1. Moreover, it is exactly the shape that we should expect to find, could account for, and remedy, by a very slight change in the eccentricity and the longitude of perihelion of the orbit of Uranus itself. In Figure 2 taken from this same publication, 1928, **36**, 356, this change has been made, and it will be seen that the perturbation of 1865 no longer exists. It has utterly vanished. With it the first perturbation of Uranus also goes.

Moreover, we know that Neptune *must* have been considerably perturbed by the Flagstaff planet, which it had only recently passed. Such a perturbation as we have just seen was detected in 1919, *Harvard Annals*, **82**, 49, and more fully described in POPULAR ASTRONOMY, 1928, **36**, 143, and 1929, **37**, 135. Now it is impossible, as may be seen by a comparison of the second and last columns of Table I, to pass a plausible orbit through this perturbation, through that of Uranus in 1865, and through the position of *O* in 1930. It therefore becomes practically certain that this supposed perturbation of Uranus never really existed. I had the perturbation of Neptune, which occurred several years before Lowell died, to help me, but excepting for that, neither of these early results seems to me now, as far as the orbit is concerned, to carry much weight. That matter will be settled later when the true orbit is found by observation of the planet itself.

With the second perturbation of Uranus, however, better success was obtained. It appears on both curves, is of the proper shape, although only 2″ in height, even being followed by a slight depression as is proper for planetary perturbations, and shows also the characteristic quality of not being appreciably affected by any small change in the elements of

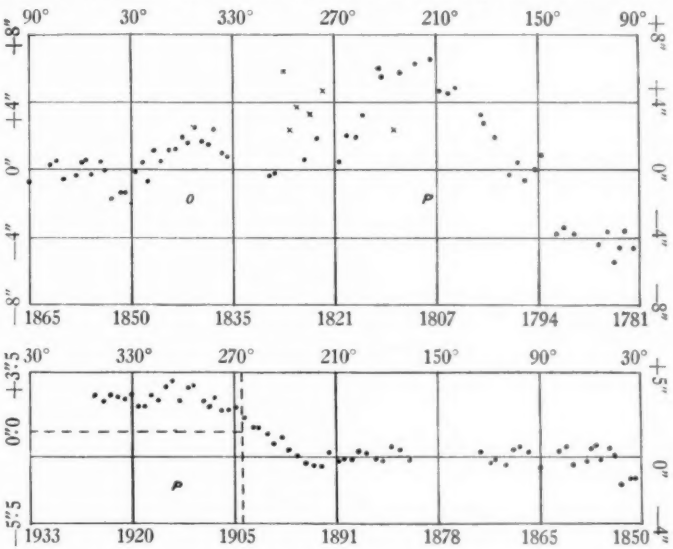


FIGURE 2.

PERTURBATIONS OF URANUS.

the orbit of the planet. After my retirement on pension from Harvard University in 1924, all my papers on planetary perturbations, with the exception of my recent letters to Professor Shapley, were published in POPULAR ASTRONOMY, and this first one, 1928, **36**, 162, gives in the text the elements of the new orbit. The second perturbation of Uranus, and the perturbation of Neptune, gave us of course only two points, and we needed a third. The only available recourse was to refer to Saturn, which should, beginning with the year 1850, have given us three perturbations. Owing to the great mass of that planet, however, and its proximity to the Sun, these were quite insignificant, but even had *O* been more massive, it is now quite certain that owing to the massive, but as yet undiscovered outer satellite of Saturn, such an investigation could never have given a really accurate result. In short, until the discovery at Flagstaff, the fact is that no astronomer had the means to compute an accurate elliptical orbit for planet *O*. All that he could do was to make an approximation to its position, which was also true in the case of Leverrier and Adams. As we have now seen both Lowell's and my

positions turned out to be reasonably accurate, at least near enough to serve for finding the planet, even after a lapse of ten and fifteen years. If, however, the last column of Table II really represents the orbit of the planet, as I believe to be the case, then in 1920.0 when my first elliptical orbit was published, the planet must have been in longitude 98°.6. Based in part on the perturbation of Neptune, the computed place as we saw in the earlier part of this paper was in longitude 97°.8, giving a deviation of only 0°.8. My error was probably greater than this, since it is unlikely that the orbit given in the table is exact. As in the case of Leverrier and Adams, the computed orbit that I published at that time was all wrong, but the location was nevertheless satisfactory. The error of Leverrier in locating Neptune was 0°.9, that of Adams 2°.4. Evidently the search for *O* was well worth making, and could have profitably been made ten years earlier, by any observatory having the suitable equipment. A number of plates were taken at Harvard at my request in 1921, with an 8-inch doublet, and exposures of one hour, in the vicinity of longitude 100°, but due perhaps in part to our having no comparator, and in part to its extreme faintness, the planet was not found upon them.

TABLE II.

ORBITS OF THE FLAGSTAFF PLANET.

Orbit	X	O^1	O^2	O^1 1930	O^2 1930
Reference date	1914.5	1920.0	1928.0	1930.2	1930.2
Date of Perihelion	(1709.8)	1720	1809	1715	1824
Longitude of Perihelion	203.8	280°	252°	270°	286°.5
Semi-major Axis	43.0	55.1	30.1	51.5	35.3
Eccentricity	0.202	0.31	0.195	0.28	0.35
Period	(282)	409	165	370	210
Longitude in 1920.0	(90.0)	97.8	—	101.6	98.6
Longitude in 1930.2	(102.2)	102.8	—	107.5	107.5

In Table II Lowell's orbit is indicated by an X, the name he gave to his planet. The orbit which I based on the first and third perturbations of Uranus and on that of Neptune we shall call O^1, that based on the second perturbation of Uranus, the three unsatisfactory ones of Saturn, and on that of Neptune, we shall call O^2. These two orbits are given as published. Each of them has been revised since the Flagstaff discovery, and these revisions are indicated by the addition of the year 1930. The last orbit, the one which we endorse, would be slightly improved by increasing the eccentricity to 0.40, and making the necessary small changes in the other three elements affected. The eccentricity is already so high, however, that it did not seem wise to make the change. Nevertheless, the occasional proximity of the small planet to both Uranus and Neptune might readily account for this peculiarity. The date of reference given by the computer is in all cases practically the date of publication. The numbers in parentheses in column X were computed by the writer from the published data. At the time that column O^1 was computed, the maximum perturbation of Neptune was thought to have occurred in 1910.0. Later corrections to their measures made by the

authorities at Greenwich and Washington, as well as later measures of the location of Neptune itself, led us to change the date of the maximum back to 1904.2, and still later to its final position 1902.4. These five orbits are plotted in Figure 3, with that of the Earth, Uranus, and Neptune to serve for comparison. The dotted lines indicate orbits predicted before the planet was actually discovered. The longitudes of their perihelia are indicated at the left, and at the bottom of the figure. The intersection of the orbit O^2 1930 with that of the orbit of Neptune is curious, and was foreseen in 1928 as shown by the dotted curve.

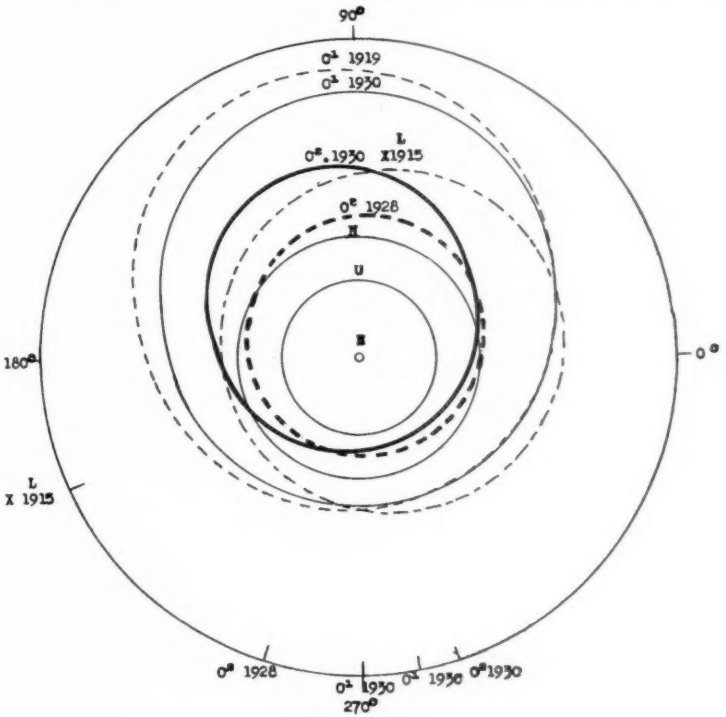


FIGURE 3.
FIVE PROPOSED ORBITS.

By a newspaper clipping I see that the suggestion has been made that this small planet is only one of a group of asteroids associated with the planet Neptune. If by asteroids is meant other planets of about the same size, we can reply to this suggestion at once with a definite negative. There are only two other clearly defined, but unexplained large perturbations of Uranus, both probably due to the same body, and in that case more massive and much more distant than planet *O*. The ap-

proximate mass of *O* is about that of the Earth, and is therefore more than a thousand times that of the largest known asteroid, as these bodies are usually defined. We can readily make a rough determination of its mass as follows. The maximum perturbation of Neptune by *O* occurred close to the aphelion of the latter, and therefore at a distance of 47.7 units. The distance of Neptune was 30.0 units, leaving the distance between them 17.7. When Neptune perturbed Uranus the amount was 90″, and the distance between them 11 units. The ratio of these distances squared, and multiplied by 90″ gives us 35″, which is the amount that Neptune would have been displaced by a body of its own mass situated at the aphelion of *O*. Since it was only really displaced about 3″, the mass of *O* must have been 1/12 as great, or 17/12 that of the Earth, the mass of Neptune being 17.

As a check on this result, let us assume that *O* has the same albedo as our Moon, 0.07. The albedo of Neptune is 0.52, its magnitude 7.6, and if it were removed to the aphelion of planet *O*, its magnitude would be reduced to 9.6. If its albedo were also reduced to that of our Moon, it would be 2.2 magnitudes fainter still, or 11.8. The reported magnitude of *O* is given as 15, or 3.2 fainter. A difference of 3.2 magnitudes corresponds to the logarithm of 1.28, and a ratio of diameters of 4.4. The diameter of Neptune is given as 31,000 miles, therefore that of planet *O* is 7000, or about the size of the planet Venus.

As since its discovery this planet seems to have excited considerable general interest, it is desirable that a name should be affixed to it as soon as is practicable. Unless a more appropriate one can be found, the writer would suggest, as he has already done in a communication regarding the planet to Professor Shapley, that it should be called Pluto, after the Greek god of Darkness, who was also able at times, when he so desired, to render himself invisible. The planet when at aphelion receives less than one 1/2000 as much light as we do from the Sun, and appears to us then only 1/19 as bright as when at perihelion. One hundred years hence it will be fully three magnitudes brighter than it is at present.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., APRIL 10, 1930.

THE PERSEID

God sent me a meteor down the Milky Way,
Dashing the path that angels fair have strolled;
But after an instant all again was still,
And only the stars that in their appointed courses move
Looked down on me.

Old legend says it is the life of man:
Brief but sometimes resplendent dash thru long eternity,
Some blazing a trail of evanescent glory,
Others a mere flash, hardly seen, against the background of the stars
That in their courses relentlessly roll.

—OSCAR E. MONNIG.

312 W. Leuda, Ft. Worth, Texas.

THE TRANS-NEPTUNIAN PLANET
(Supplementary Note)*

By WILLIAM H. PICKERING.

A few words in addition may be said regarding Lowell's investigation of this interesting object, as it appears to the writer. His publication is undoubtedly a very "elegant" mathematical investigation, showing high mathematical ability and great resource, but it seems to me that the mathematics is out of place, and should be replaced by common sense. In the case of the discovery of Neptune the perturbation was enormous in proportion to the accidental errors, and the mathematics fully justified. Such was by no means the case with planet *O*, where the perturbation was comparatively small. In fact as we have I believe shown, the largest recent perturbation on which Lowell's investigation was founded, did not exist at all, and the remote ones on which he places considerable reliance, going back to 1690, are of very doubtful value. In fact as is shown by Figure 2, between the years 1854 and 1897, that is for half a revolution, Uranus experienced no appreciable perturbation whatever. The clinching argument against the existence of the perturbation of Uranus in 1865, as combined with the obvious perturbation of Neptune in 1902, and the observed position of *O*, was the actual finding of *O* at his own observatory.

If instead of accepting Gaillot's deviations as they stood, Lowell had gone back to the original work of Leverrier, as he did at first, and as did the writer, it is quite possible that with his own sense of proportion, and the common sense with which he was favored, he would have changed the whole current of his investigation. In any case I do not wish it thought that my criticisms of his work are made in a spirit of rivalry. What I have stated is explicit and clear. If the investigations of others prove that I am mistaken, that the deviation of Uranus in 1865 was a true perturbation caused by *O*, I shall then be only too glad to acknowledge my error. Lowell and I were at one time more or less personal friends, and throughout his life I backed him in his Martian work far more fully, I believe, than did any other professional astronomer, because I believed that he was largely right. It was only because I was unwilling to back him in all his theories, and because I said so, that we later, to my regret, became more or less estranged. He was glad and appreciative of my favorable comments on his work, but hurt by those of my criticisms that were unfavorable.

I wish now to point out that all of us who are interested in the new planet, and I myself in particular, owe Lowell a distinct debt of gratitude. Had he not established his observatory at a very considerable expense, and had his former assistants not continued his work of search-

*This additional note was received from Professor W. H. Pickering after the preceding form was printed, hence the apparent awkwardness in the arrangement.—Ed.

ing for the unknown planet, it is highly probable that it would not have been discovered for another hundred years, that is until it had again perturbed the planet Uranus. Then possibly the perturbation of Uranus in 1841, and that of Neptune in 1902, would have been recalled, and with these three definite points on the orbit settled, the planet would have been immediately found. It is altogether too faint an object to believe that it would previously have been discovered by accident. The importance of the work of the Lowell Observatory is indicated by the fact that, although I apparently computed the place of the planet in 1919 within an accuracy of 1°, yet no observatory furnished with a blink comparator, and a sufficiently powerful telescope, thought it worth while to look and see if the planet was really there. If the only astronomical work that Lowell had done was to build his observatory, and plan that his former assistants should look for the unknown planet, that should be sufficient to establish his place in astronomical biography. In closing I therefore say all honor to the late Dr. Lowell.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., APRIL 15, 1930.

PLANET NOTES FOR JUNE

By CLIFFORD E. SMITH.

The *Sun* will move, apparently, from the central part of Taurus to the central part of Gemini. On June 22 the sun will be at the summer solstice, which officially marks the beginning of summer. The positions of the sun on the first and last day of the month will be respectively: R.A. $4^h\,32^m$, Decl. $+21°\,56'$; and R.A. $6^h\,33^m$, Decl. $+23°\,14'$.

The phases of the *Moon* will occur as follows:

First Quarter	June	3 at	4 P.M.	C.S.T.
Full Moon		10 "	12 P.M.	"
Last Quarter		19 "	3 A.M.	"
New Moon		26 "	8 A.M.	"

The moon will be at apogee (farthest from the earth) on June 16, and at perigee (nearest the earth) on June 28.

Mercury will be in Taurus, moving from the western to eastern part of the constellation. Its magnitude will be about 1.5 at the beginning of the month, and —0.6 at the end of the month. On June 15 Mercury will be at greatest elongation west, and on this date it will rise about an hour and a quarter before the sun. On June 25 it will be in conjunction with the moon.

Venus will be moving easterly from the central part of Gemini, across Cancer, to the western part of Leo. Its magnitude during this period will be about —3.4. On June 29 it will be in conjunction with the moon. During this period it will set about two hours after the sun.

Mars will be in Aries, and during the month it will move from the western to the eastern part of the constellation. Its brightness will be slowly increasing to about magnitude 1.3 at the end of the month. On June 23 Mars will be in conjunction with the moon. At the beginning of the month it will be on the meridian about 9 A.M. Standard Time.

Jupiter will be near the sun in apparent position during this period, conjunction with the sun occurring on June 20.

Saturn will be in central Sagittarius, and its apparent motion will be retrograde. On June 12 it will be in conjunction with the moon. Near the end of the month Saturn will be approximately on the meridian at midnight since opposition occurs on July 1, and its apparent magnitude will be 0.3.

Uranus will be in central Pisces. On June 20 it will be in conjunction with the moon. During the middle of the month it will be on the meridian about 7 A.M. Standard Time. It will be remembered that Uranus is just visible to the unaided eye under most favorable conditions.

Neptune will be in Leo about two degrees southeast from Regulus. On June 2 and on June 30 it will be in conjunction with the moon. At the end of the month it will be on the meridian about 3 P.M. Standard Time. Neptune has an average magnitude about eight which is some sixteen times fainter than the faintest objects which can be seen with the unaided eye.

Trans-Neptunian Planet.—The new information which has been secured concerning this new planet since the preceding issue of this journal has been transmitted chiefly by the *Harvard College Observatory Announcement Cards*. We give here the several items for the benefit of those who may not have access to this source.

TRANS-NEPTUNIAN PLANET. The following three observations of the Lowell planet have been received from Professor D. W. Morehouse of Des Moines, Iowa.

1930 U.T.	R.A. 1930.0 (h m s)	Dec. 1930.0 (° ′ ″)
March 19.2097	7 15 37.9	+22 7 27.9
20.1597	7 15 36.8	+22 7 34.4
26.1597	7 15 31.5	+22 8 7.8

The positions were determined by Mehlin from plates taken with the 8¼-inch refractor at Drake University.

Announcement Card 117. HARLOW SHAPLEY.
April 1, 1930.

TRANS-NEPTUNIAN PLANET. A telegraphic report received yesterday from Berkeley states that a preliminary investigation of the orbit of the Lowell Observatory object completed at the Students' Observatory of the University of California by E. C. Bower and F. L. Whipple under the general direction of Professor A. O. Leuschner has resulted in a group of solutions giving a fairly well determined distance from the earth of approximately forty-one astronomical units. With the assumption, justified by this distance, that the principal part of the body's motion in the line of sight is due to the earth's annual motion, Messrs. Bower and Whipple found $i = 17°$, $\Omega = 109°$. Solutions with approximately the same distance, accurately representing observations from March 16 to April 4, gave orbits varying from a near circle to a parabola with $q = 17$, so that no definite conclusion concerning the eccentricity and period can be drawn without observations covering a considerably longer interval. All solutions give approximately the same node and inclination. At present it is not even possible to decide whether the orbital motion of the object is directed toward or away from the earth.

The investigation was made possible primarily through the coöperation of Associate Director Aitken of the Lick Observatory who promptly arranged for a series of observations by Professor F. W. Meyer. Of importance also were two observations by Dr. Van Biesbroeck at the Yerkes Observatory on March 16 and

17. It is improbable but not impossible, Professor Leuschner adds, that computations based on more extended observations will materially change the distance, inclination, or node.

Announcement Card 118. HARLOW SHAPLEY.
April 7, 1930.

TRANS-NEPTUNIAN PLANET. A radiogram received yesterday from Professor Banachiewicz of Cracow gives the following circular solution of the orbit of the Trans-Neptunian planet from observations of March 16 to 26:

Epoch	1930 March 21.064
Argument of latitude (u)	—0° 48′
Node (☊)	109° 42′
Inclination (i)	13° 5′
Daily motion	15″.6
Distance from Sun (q)	37

Announcement Card 119. HARLOW SHAPLEY.
April 8, 1930.

TRANS-NEPTUNIAN PLANET. A radiogram received from Professor Banachiewicz of Cracow, Poland, transmits the following ephemeris of the Trans-Neptunian planet, computed by Kordylewski from new elements derived by Banachiewicz.

1930 U.T.		R.A. 1930.0 h m s	Dec. 1930.0 ° ′ ″
April	12.0	7 15 37.0	+22 9 10
	16.0	7 15 42.6	+22 9 16
	20.0	7 15 49.8	+22 9 20
	24.0	7 15 58.5	+22 9 20
	28.0	7 16 8.9	+22 9 17
May	2.0	7 16 20.7	+22 9 11

Announcement Card 120. HARLOW SHAPLEY.
April 11, 1930.

TRANS-NEPTUNIAN PLANET. The following telegraphic communication from Flagstaff was received on April 13:

"Preliminary orbit Planet X has been computed by Lowell Observatory staff with collaboration of Dr. John A. Miller, director of the Sproul Observatory, using positions January 23, February 23, and March 23 determined from Lowell plates by Lampland and yielded following elements referred to mean equinox 1930.0.

Node	109° 21′
Inclination	17° 21′
Log. semi-major axis	2.3359
Longitude perihelion	12° 52′
Eccentricity	0.909
Mean daily motion	1″.112
Mean anomaly 1930.0	3° 20′ 47″
Distance from Sun	41.3

Position computed from orbit for March 30 checked observed position within small fraction of one second of arc in both coördinates. However, because of very short arc available and object's extremely small latitudes, considerable revision of some elements, especially eccentricity, is not unexpected. Our first preliminary circular orbit computed from positions January 23 and March 23 had given node and inclination agreeing with these of elliptic orbit. Further details will appear promptly in *Lowell Circular*. V. M. Slipher."

Announcement Card 121. HARLOW SHAPLEY.
April 14, 1930.

Occultations Visible at Washington

[From the *American Ephemeris.*]

Date 1930	Star	Mag.	IMMERSION Washington C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Washington C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
June 3	308 B.Leo	5.8	21 43	—0.4	—2.2	152	22 40	—0.8	—1.6	278
9	41 G.Sco	6.3	19 27	—2.0	+2.6	65	20 10	+0.4	—1.6	349
10	σ Sco	3.0	0 54	..	..	173	1 25	..	..	217
11	38 B.Sgr	4.7	21 11	—1.3	+1.5	81	22 24	—1.1	+0.2	303
	C.D.—28°14268	6.4	23 59	..	..	157	0 41	..	..	213
12	62 B.Sgr	6.0	3 6	—1.6	—0.8	88	4 24	—1.0	—0.9	256
14	86 B.Cap	6.2	23 40	—1.1	+1.0	106	0 51	—1.8	+1.9	226
16	143 B.Cap	6.1	0 56	—1.5	+2.0	55	2 21	—2.0	+1.1	258
18	ψ^3 Aqr	4.6	4 31	—1.7	+1.5	53	5 58	—1.5	+1.1	227
29	107 B.Leo	6.3	21 45	0.0	—1.0	82	16 56	+0.5	—1.7	329

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 or 300 miles of Washington. The procedure is as follows: Subtract the longitude of Washington (77°.1) from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude (38°.9) using *b*; apply the sum of the products, with its proper sign, to the Washington C.T., and obtain the predicted Washington Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to add 8.3 minutes to Washington Civil Time.

Occultations Visible at Omaha and Vicinity.

(Disappearances Only)

Date 1930	Star	Mag.	G.C.T.	*a*	*b*	P
			h m	m	m	°
June 4	308 B. Leonis	5.8	2 42	+0.6	—3.9	187
30	107 B. Leonis	6.3	2 56	—0.4	+1.0	98

The approximate times for observers within 300 miles of Omaha can be found by using the constants *a* and *b*, given in the table, according to the formula

$$\text{G.C.T.} = \text{Predicted G.C.T.} + a\Delta\lambda + b\Delta\Phi,$$

$\Delta\lambda$ and $\Delta\Phi$ in this case being obtained by using the longitude (96°.0) and latitude (41°.3) of Omaha, and subtracting these, respectively, from the longitude and latitude of the place.

Wm. Cletus Doyle, S.J.

Creighton University Observatory.

VARIABLE STARS

Monthly Report of the American Association of Variable Star Observers for March, 1930.

Very commendable reports have been received this month from Messrs. Ahnert, Peltier, Lacchini, Chandra, Baldwin, and Houghton. Nearly 400 variables are listed and the total number of observations is nearly 2200; not a bad record for this season of the year. We welcome back to the ranks of active observers Mr. Nakamura of Japan and Miss Hawes of Vassar. We also list the

Variable Star Observations Received During March, 1930.

Jan. 0 = J.D. 2425977; Feb. 0 = J.D. 2426008; March 0 = J.D. 2426036.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V Scl	S Tuc	X Scl	U Scl	U Per	T Per
000339	*001862*	*004435*	*010630*	015254	021258
983[13.3 Bl	987 10.4 Ht	005 11.3 Bl	983[13.5 Bl	022 8.3 Ah	047 8.5 BL
998[12.6 Sm	995 10.2 Sm	RR And	005[13.2 Bl	026 8.2 Pt	050 8.5 BL
002[12.6 En	995 10.5 Bl	004533	U And	027 8.2 Ah	052 8.7 BL
S Scl	000 10.2 Ht	986 11.0 Nz	010940	028 8.2 Ah	Z Cep
001032	000 10.0 En	996 10.2 Nz	005 9.7 Ch	028 8.4 B	021281
980 9.9 Ht	002 10.1 Bl	002 9.8 Nz	015 10.1 L	029 8.3 Ah	015 11.4 L
983 9.1 Sm	006 10.2 Sm	005 9.1 Ch	029 10.2 B	030 8.1 Ah	026 11.9 Pt
983 9.4 Bl	007 10.1 Ht	006 9.6 Nz	UZ And	032 8.2 Ah	033 12.9 B
987 10.0 Ht	S Cet	028 8.4 B	011041	033 8.4 Ch	035 12.7 Br
995 10.3 Bl	*001909*	RV Cas	005 9.4 Ch	034 8.2 Ah	o Cet
997 10.0 Sm	000 8.5 Ch	004746a	028 11.2 Ma	036 8.0 Ah	*021403*
000 10.4 Ht	025 9.0 L	005 12.0 Ch	028 10.4 B	038 8.2 Ah	997 9.4 Sm
001 10.1 En	026 8.7 Pt	026 9.5 Pt	S Psc	039 8.1 Ah	000 9.2 En
005 10.6 Bl	T Scl	034 9.5 B	011208	XX Per	007 9.1 En
007 10.5 Ht	*002438a*	— Cas	025[13.9 L	015654	010 9.6 Ch
X And	002 9.8 En	004746b	S Cas	033 8.4 Ch	016 9.1 Ah
001046	T Phe	026 10.4 Pt	011272	S Ari	022 9.0 Ah
986 13.1 Nz	*002546*	W Cas	028 13.1 B	015912	025 9.1 L
996[14.6 Nz	983[12.2 Sm	004958	032 12.9 Ch	033[14.0 B	025 9.8 Jo
002[14.2 Nz	987[13.2 Ht	005 8.6 Ch	035 12.9 Br	035 14.2 L	026 9.1 BL
006[14.4 Nz	997[12.2 Sm	026 8.9 Pt	U Psc	R Ari	026 9.3 Pt
029[13.5 B	000[13.2 Ht	026 9.1 BL	011712	021024	027 9.0 Ah
T And	002[13.0 En	026 9.0 Jo	025 13.3 L	006 9.3 Ch	028 9.1 BL
001725	005 13.6 Bl	028 8.5 B	RZ Per	011 9.6 Ah	029 8.9 Ah
026 12.0 Pt	W Scl	028 9.0 BL	012350	015 9.6 L	030 9.0 Ah
028 12.0 Ch	*002833*	029 9.2 Jo	006 9.8 Ch	016 9.8 Ah	032 9.0 Ah
T Cas	983 13.0 Bl	030 9.1 Ah	015 9.9 L	022 10.0 Ah	033 9.0 BL
001755	997[12.8 Sm	032 9.4 Ah	029 10.2 B	023 10.0 Ah	036 10.0 Jo
016 9.8 Ah	Y Cep	033 9.3 BL	R Psc	026 10.7 Pt	038 9.1 Ah
022 10.0 Ah	003179	034 9.4 BL	012502	027 10.2 Ah	040 9.0 BL
025 11.4 Jo	035[13.9 Br	034 9.1 Ah	979 8.9 Nz	029 10.5 Ah	047 9.0 BL
026 11.3 Pt	U Cas	036 9.4 Ah	986 8.7 Nz	030 10.4 Ah	S Per
027 11.3 Ah	004047	036 8.9 Jo	996 9.6 Nz	032 10.7 Ah	021558
028 10.9 B	015 12.3 L	038 9.6 Ah	002 9.6 Nz	033 10.5 B	026 9.4 BL
028 10.9 Ch	026 10.9 Pt	039 9.4 Ah	006 10.1 Ch	033 10.6 Ch	026 8.9 Pt
029 11.5 Jo	028 10.5 B	040 9.3 BL	007 9.7 Nz	034 10.7 Ah	027 9.4 Ah
029 11.5 Ah	033 10.5 Sf	042 9.4 BL	022 10.5 Ah	036 10.7 Ah	028 9.4 BL
034 11.5 Ah	035 10.4 L	047 9.5 BL	026 11.6 Pt	038 10.9 Ah	029 9.5 B
035 11.3 L	040 10.0 Sf	050 9.5 BL	RU And	W And	030 9.4 Ah
036 11.5 Jo	046 10.1 Md	052 9.5 BL	013238	021143a	033 9.4 BL
R And	RW And	U Tuc	006 12.8 Ch	006 12.8 Ch	034 9.3 BL
001838	004132	*005475*	015 13.1 L	026 12.0 Pt	034 9.4 Ah
016 9.5 Ah	005 13.4 Ch	980 12.1 Ht	026 13.8 Pt	028 12.1 B	038 9.2 Ah
022 10.0 Ah	015 13.1 L	983 12.2 Bl	029 13.4 B	028 12.0 Ch	040 9.4 BL
026 9.5 Pt	028 13.6 B	993 13.0 Ht	Y And	T Per	042 9.3 BL
027 10.0 Ah	V And	995 13.0 Bl	013338	021258	047 9.2 BL
028 10.0 Ch	004435	995 12.9 Sm	026 12.7 Pt	026 8.5 BL	050 9.2 BL
029 10.1 Ah	986 9.5 Nz	000 12.9 Ht	028 12.8 B	026 8.6 Pt	052 9.3 BL
030 10.2 Ah	996 9.4 Nz	002 13.0 Bl	X Cas	027 8.7 Ah	R Cet
032 10.3 Ah	002 9.5 Nz	006 13.1 Sm	014958	028 8.5 BL	*022000*
034 10.3 Ah	005 9.5 Ch	007 13.1 Ht	024 12.2 Bn	030 8.6 Ah	000 8.5 Ch
034 10.2 B	006 9.4 Nz	Z Cet	026 12.0 Pt	033 8.6 BL	025 8.1 L
038 10.7 Ah	029 10.1 B	*010102*	028 11.6 B	034 8.3 BL	025 8.0 Jo
S Tuc	X Scl	005 11.3 Ch	034 12.2 Bn	034 8.7 Ah	027 8.6 Sf
001862	*004435*	025 12.3 L	U Per	038 8.8 Ah	028 8.0 Ch
980 11.3 Ht	983 11.2 Bl	026 12.5 Pt	015254	040 8.6 BL	032 8.4 Jo
983 10.5 Bl	995 11.1 Bl		016 8.4 Ah	042 8.4 BL	033 8.7 Sf

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

R CET
022000
036 8.5 Jo

RR PER
022150
026 13.4 Pt
028 13.5 B
035 14.6 L

R FOR
022426
983 8.7 Bl
995 8.5 Bl
002 8.6 Bl

U CET
022813
001 8.0 Ch
026 8.8 Pt

RR CEP
022980
026 12.5 Pt

R TRI
023133
006 6.8 Ch
011 7.2 Ah
016 7.3 Ah
021 7.3 Ah
022 7.4 Ah
023 7.5 Ah
023 7.7 Tf
025 7.8 Jo
026 7.9 Pt
027 7.6 Ma
027 8.0 Sf
027 7.8 Ah
029 7.9 Ah
029 8.0 Jo
030 8.0 Ah
032 8.1 Ah
033 8.1 B
033 8.2 Sf
034 8.1 Ah
035 8.4 Gv
036 8.4 Tf
036 8.3 Ah
036 8.2 Jo
037 8.4 Ah
038 8.3 Ah
039 8.3 Ah
040 8.6 Sf
051 8.7 Ma

T ARI
024217
022 9.6 Ah
029 9.6 Ah
030 9.7 Ah
034 9.7 Ah
037 9.8 Ah
038 9.8 Ah
039 9.9 Ah

W PER
024356
917 9.1 Nk
918 9.1 Nk
006 10.4 Ch
025 10.3 Jo
026 9.8 Pt
028 10.0 B
029 10.5 Jo
030 9.9 Ah
034 10.4 Ah
036 10.6 Ah
036 10.5 Jo
038 10.1 Ah
039 10.4 Ah

R HOR
025050
980 11.2 Ht
983 10.8 Bl
987 11.2 Ht
995 10.3 Bl
995 10.6 Sm
000 10.2 En
000 10.4 Ht
002 10.1 Bl
006 10.2 Sm
007 9.8 Ht

T HOR
025751
983 12.8 Bl
995 13.0 Bl
000[12.7 Ht
002 13.0 Bl
007[12.7 Ht

U ARI
030514
979 14.7 Nz
007 14.7 Nz
025 14.6 L
033[14.0 B

X CET
031401
006 10.9 Ch
025 11.7 L
026 11.9 Pt
033 12.1 B

Y PER
032043
917 9.9 Nk
943 9.8 Nk
006 8.2 Ch
008 8.1 Nk
026 8.0 BL
026 8.0 Pt
027 8.4 Ah
028 8.0 BL
029 8.5 B
029 8.7 Ah
030 8.4 Ah

Y PER
032043
032 8.4 Ah
033 8.3 BL
034 8.2 BL
034 8.4 Ah
036 8.5 Ah
038 8.4 Ah
039 8.5 Ah
040 8.2 BL
042 8.9 Sr
042 8.9 Ku
042 8.8 Gb
042 8.6 BL
047 8.3 BL
050 8.4 BL
052 8.2 BL

R PER
032335
006 8.3 Ch
015 8.7 L
026 8.5 Pt
029 9.2 B
035 9.0 L
046 9.5 Md

T FOR
032528
023 9.4 L

U ERI
034625
997[12.6 Sm
035 14.0 L

R TAU
042209
979 11.7 Nz
989 12.3 Nz
995 12.5 Nz
001 12.7 Nz
010 12.4 Ch
026 13.0 Pt
029 13.6 B

W TAU
042215
009 11.2 Ch
023 11.3 L
025 11.0 Jo
026 10.8 Pt
028 11.2 B
029 11.3 Jo
032 11.3 Jo
035 11.5 Al
036 11.8 Jo

S TAU
042309
979[14.8 Nz
995[14.8 Nz
001[14.8 Nz

T CAM
043065
892 9.0 BR
900 9.4 BR
922 9.9 BR
010 12.8 Ch
023 13.2 L
026 13.1 Pt
028 13.0 Ch

RX TAU
043208
010 14.0 Ch
025 14.0 L
026 13.2 Pt
029 13.8 B

R RET
043263
995 13.0 Bl
002 12.5 Bl
006 12.5 Sm
007 12.4 En
007 12.5 Ht

X CAM
043274
023 12.6 L
026 12.4 Pt
028 12.8 Ch
029 12.7 B

R DOR
043562
980 5.5 Ht
983 5.6 Bl
987 5.5 Ht
995 5.8 Bl
995 5.2 Sm
997 5.5 En
000 5.6 Ht
002 6.0 Bl
002 5.9 En
005 6.0 Bl
006 5.2 Sm
007 6.0 En

R CAE
043738
983 11.5 Bl
984 11.6 Ht
995 11.7 Bl
998 11.9 Sm
000 12.0 Ht
005 11.7 Bl
007 11.8 Ht
007 11.8 En

R PIC
044349
982 7.3 Ht
983 7.0 Bl
993 7.7 Ht
995 7.7 Bl
997 7.7 Sm

R PIC
044349
000 7.9 Ht
005 7.7 Bl
006 8.2 Sm
007 8.3 En
007 8.2 Ht

V TAU
044617
010 13.2 Ch
028 13.8 B

R ORI
045307
025 11.0 L
026 10.8 Ch
028 10.7 B
046 11.3 Md

R LEP
045514
944 7.2 Nk
951 7.1 Nk
002 7.4 Ch
023 6.8 Tf
025 7.1 L
025 6.8 Jo
026 6.6 Pt
027 7.1 Ma
029 7.0 Jo
029 7.8 B
030 6.5 Bc
031 6.5 Bc
036 6.5 Jo

V ORI
050003
989 10.0 Nz
995 9.4 Nz
001 9.0 Nz
025 9.3 L
026 9.5 Pt
026 9.3 Ch
027 9.4 Ah
028 9.5 B
029 9.3 Ah
030 9.6 Ah
034 9.6 Ah
036 9.9 Ah
038 10.0 Ah
039 10.0 Ah

T LEP
050022
983 8.4 Bl
989 8.7 Nz
995 8.2 Nz
995 8.7 Bl
997 8.5 Sm
997 8.0 En
001 8.7 Nz
005 7.9 Bl
007 8.0 En

T LEP
050022
026 9.1 Pt
029 8.6 B

S PIC
050848
982 9.7 Ht
983 9.7 Bl
993 9.9 Ht
995 10.2 Bl
997 10.2 Sm
997 10.2 En
000 10.2 Ht
005 10.6 Bl
007 10.4 Ht
007 10.6 En

R AUR
050953
026 12.2 Pt
026 12.0 Ch

T PIC
051247
982 11.8 Ht
983 11.6 Bl
993 11.2 Ht
995 10.7 Bl
000 10.6 Ht
005 10.1 Bl
007 10.0 Ht
007 9.5 En

NOV TAU
051315
025 14.2 L

T COL
051533
983 10.8 Sm
983 11.1 Bl
984 10.8 Ht
995 11.7 Bl
000 11.7 Ht
005 11.3 Bl
006 11.1 Sm
007 11.9 Ht

S AUR
052034
026 9.5 BL
026 8.8 Pt
026 9.4 Ch
028 9.5 BL
029 10.1 Ah
030 9.9 Ah
033 9.6 BL
034 9.5 BL
034 9.3 Ah
036 9.8 Ah
038 10.0 Ah
039 10.0 Ah
040 9.7 BL
042 9.8 BL

Variable Star Observations Received During March, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

S Aur
052034
043 8.8 Lg
046 9.9 BL
047 9.7 BL
050 9.8 BL
052 9.8 BL

W Aur
052036
025 13.7 L
026 13.8 Pt
026 13.4 Ch
034 13.7 B

S Ori
052404
009 12.1 Ch
011 10.6 Ma
026 11.4 Pt
027 10.4 Ma
028 10.2 B
051 9.6 Ma

T Ori
053005a
944 10.8 Nk
951 10.7 Nk
996 10.0 Nk
009 9.7 Ch
010 10.0 L
011 10.0 Ma
015 9.8 L
021 10.4 Pt
022 10.2 Pt
023 9.7 Pt
023 9.8 L
025 10.0 L
026 10.2 Pt
026 9.8 Ch
027 9.2 Ma
027 10.0 Pt
028 9.8 L
028 10.0 B
028 10.0 Pt
029 9.8 Pt
031 10.2 Pt
034 9.8 Pt
035 9.9 L
036 10.0 Pt
040 9.7 Pt
041 9.9 Pt
042 10.5 Jo
042 9.7 Lg
043 9.6 Lg

AN Ori
053005t
015 11.6 L
025 11.6 L
035 11.6 L

S Cam
053068
026 8.3 BL

S Cam
053068
026 7.9 Pt
027 8.7 Ah
028 8.5 BL
033 8.5 BL
034 8.5 BL
040 8.4 BL
046 8.5 BL
047 8.6 BL
050 8.6 BL
052 8.6 BL

RR Tau
053326
980 12.5 Nz
995 13.0 Nz
996 13.2 Hs
001 13.3 Nz
003 13.2 Hs
010 13.6 L
015 13.5 L
023 13.5 L
025 13.1 L
028 11.9 L
029 12.1 B
035 11.8 L

RU Aur
053337
026[12.0 Pt
026[13.4 Ch

U Aur
053531
022 9.3 Ah
023 9.3 Ah
025 9.0 L
026 9.4 Pt
026 9.2 Ch
027 9.3 Sf
027 9.2 Ah
028 9.1 Ah
029 9.1 Ah
030 9.2 Ah
034 9.1 Ah
034 9.2 B
036 9.6 Sf
036 9.1 Ah
037 9.1 Ah
038 9.1 Ah
039 9.2 Ah

SU Tau
054319
002 9.8 Ch
011 9.3 Ma
015 9.6 L
021 9.6 Pt
022 9.7 Pt
023 9.6 Pt
023 9.6 L
025 9.5 L
026 9.6 Pt

SU Tau
054319
027 9.3 Ma
027 9.6 Pt
028 9.6 Pt
028 9.6 Br
028 9.5 L
029 9.6 Br
029 9.6 Pt
030 9.6 Br
031 9.6 Pt
033 9.8 Ch
034 9.6 Pt
034 9.7 Br
035 9.6 Br
035 9.5 L
036 9.6 Pt
037 9.6 Br
038 9.9 Pt
040 9.7 Pt
040 9.5 Br
040 9.5 Ma
041 9.7 Pt
046 9.4 Ma

S Col
054331
983 11.9 Sm
983 12.0 Bl
984 12.0 Ht
995 12.7 Bl
998 12.2 Sm
000 12.6 Ht
005 12.1 Bl

Z Tau
054615a
995 14.0 Nz
001 13.7 Nz
025 13.7 L

RV Tau
054615b
026 9.4 Ch

RU Tau
054615c
989 10.2 Nz
995 10.4 Nz
001 10.4 Nz
025 11.5 L
026 10.9 Ch

R Col
054629
983 10.9 Sm
983 10.4 Bl
984 10.6 Ht
995 10.9 Bl
998 11.9 Sm
000 11.7 Ht
005 11.5 Bl
007 11.9 Ht

α Ori
054907
015 0.2 L

U Ori
054920a
917 7.4 Nk
944 7.1 Nk
950 7.4 Nk
951 7.4 Nk
997 8.3 Nk
004 8.6 Nk
008 8.7 Nk
011 8.9 Ah
022 9.1 Ah
023 9.1 Ah
025 9.0 Jo
026 8.8 Fd
026 9.0 Ch
026 9.0 Pt
027 9.2 Ah
027 9.4 Fd
028 9.0 B
028 9.1 Ah
028 9.5 Wd
029 9.7 Wd
030 9.2 Ah
032 9.2 Ah
032 9.2 Jo
034 9.3 Ah
035 9.4 Al
036 9.2 Ah
036 9.8 Wd
038 9.4 Ah
039 9.4 Ah
040 9.5 Jo
041 11.2 Fd
042 9.8 Wd

V Cam
054974
025 14.9 L

Z Aur
055353
021 10.0 Pt
022 10.0 Pt
023 10.0 Pt
026 10.1 Pt
027 10.2 Pt
027 9.8 Ah
028 10.1 Pt
029 10.0 Pt
029 10.0 Ah
030 10.0 Ah
031 10.2 Pt
034 10.0 Pt
034 9.8 Ah
035 9.5 Al
036 10.0 Pt
038 10.2 Pt
039 9.9 Ah
040 9.8 Pt

Z Aur
055353
041 10.0 Pt
043 9.7 Lg
045 10.0 Pt

R Oct
055686
983 12.7 Bl
995[12.5 Bl
005 12.7 Bl

X Aur
060450
017 12.0 Lj
019 11.8 Lj
026 11.2 Pt
026 11.2 Ch
028 11.3 L
028 11.3 Lj
032 11.0 Lj
033 10.4 Ch
036 10.3 Lj

V Aur
061647
030 11.4 Ch
036 10.7 L

V Mon
061702
010 11.8 Ch
026 12.2 Pt
030 12.8 Br
035 12.6 Al

AG Aur
062047
023 9.6 L
036 9.3 L

R Mon
063308
010 12.6 Ch
026 10.8 Pt
035 11.7 B

Nov Pic
063462
979 8.2 En
980 8.4 Ht
987 8.1 Ht
997 8.2 En
998 8.2 Sm
000 8.3 Ht
007 8.4 Ht
007 8.2 En

S Lyn
063558
007 10.0 Ch
026 11.0 Pt
029 11.4 Bw
036 12.1 L

X Gem
064030
024 11.1 Bn
029 11.1 Bw

X Gem
064030
030 10.7 Bn
034 10.7 Bn
043 10.5 Bn

W Mon
064707
034 9.6 B

Y Mon
065111
010 13.8 Ch

X Mon
065208
023 9.5 Tf
025 9.1 L

R Lyn
065355
036 12.6 L

V CMi
070109
010 14.0 Ch
037[13.7 B

R Gem
070122a
000 7.4 Ch
016 7.6 Ah
021 7.7 Ah
022 7.8 Ah
023 7.8 Ah
025 7.9 Wd
026 7.5 Pt
027 8.0 Ah
028 8.1 Ah
028 8.4 Wd
029 8.6 Wd
029 8.0 Ah
030 8.2 Ah
032 8.2 Ah
034 8.4 Ah
034 8.7 Br
035 7.2 Al
036 8.8 Wd
036 8.4 Ah
037 8.4 Ah
038 8.5 Ah
039 8.5 Ah
042 9.5 Wd

Z Gem
070122b
026 12.4 Pt

TW Gem
070122c
026 12.4 Pt

R CMi
070310
002 11.4 Ch
023 11.0 L
030 10.4 Al

Variable Star Observations Received During March, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

R Vol
070772
982 10.9 Ht
993 10.7 Ht
995 11.3 Sm
000 10.9 Ht
007 10.9 Ht

RR Mon
071201
010[13.4 Ch
030 12.8 Br

V Gem
071713
034 14.0 B
036 13.4 L

S CMi
072708
944 8.0 Nk
951 8.3 Nk
010 11.0 Ch
025 10.2 Jo
026 11.2 BL
026 11.3 Pt
028 11.3 BL
032 10.5 Jo
033 11.4 BL
034 11.4 BL
037 11.6 Br
040 10.7 Jo
040 11.5 BL
047 11.6 BL
050 11.7 BL
052 11.8 BL

T CMi
072811
010 13.2 Ch
030 13.9 B
036 13.2 L

Z Pup
072820b
985 14.3 Nz
995 14.2 Nz
001 14.4 Nz

S Vol
073173
983 13.4 Bl
995 12.9 Bl
995 13.2 Sm
000 12.5 Ht
005 12.6 Bl
006 13.2 Sm
007 12.2 Ht

U CMi
073508
023 11.8 L
026 12.1 Pt
030 12.1 Br
035 12.4 B

S Gem
073723
996 9.8 Hs
003 9.5 Hs
010 9.5 Ch
026 9.8 Pt
034 10.2 Br
035 10.7 Bw

W Pup
074241
980 12.3 Ht
983 12.4 Bl
983 11.9 Sm
993 11.9 Sm
993 12.1 Ht
995 12.1 Bl
997 11.9 En
000 11.7 Ht
005 11.0 Bl
006 11.5 Sm
007 11.2 Ht

T Gem
074323
010 8.8 Ch
022 8.7 Ah
023 8.8 Ah
026 8.6 Pt
027 8.9 Ah
028 8.9 Ah
030 8.9 Ah
032 8.9 Ah
034 8.9 Ah
035 8.6 Bw
035 8.5 Br
036 8.8 Ah
037 8.8 Ah
038 8.9 Ah
039 9.1 Ah

U Pup
075612
010[13.2 Ch
029[13.2 Bw
035[13.5 B

R Cnc
081112
010 10.3 Ch
025 10.2 Bc
026 10.0 Pt
027 10.0 Ah
029 10.0 Ah
030 10.0 Ah
030 9.8 Bc
032 9.9 Ah
033 9.7 B
034 9.9 Ah
036 10.0 Ah
037 9.8 Ah
038 9.8 Ah
039 9.9 Ah
040 10.0 Jo

R Cnc
081112
042 10.1 Jo
044 9.8 Fd

V Cnc
081617
010 9.4 Ch
026 9.3 Pt
027 9.1 Ah
029 9.2 Ah
030 9.2 Ah
030 9.0 Br
032 9.0 Ah
034 9.0 Ah
035 8.9 Gy
035 9.0 B
036 8.7 L
036 9.0 Ah
037 8.9 Ah
038 9.0 Ah
039 8.9 Ah
041 9.0 Fd

RT Hya
082405
026 7.5 Pt

R Cha
082476
979 8.1 En
982 8.0 Ht
983 7.7 Bl
983 8.1 Sm
993 8.0 Ht
995 8.2 Sm
995 8.0 Bl
000 8.2 Ht
002 8.3 En
005 8.0 Bl
006 8.4 Sm
007 8.7 En
007 8.6 Ht

U Cnc
083019
009 11.4 Ch
030 11.8 Br
035 11.8 B
036 11.7 L

X UMa
083350
026 10.2 Pt
033 10.7 B

S Hya
084803
010 7.2 Ch
016 7.4 Ah
022 7.4 Ah
023 7.5 Ah
026 7.6 Pt
027 7.8 Ah
028 7.7 Ah
029 7.9 Ah

S Hya
084803
030 7.7 Ah
030 7.5 Br
032 7.7 Ch
032 8.0 Ah
034 8.1 Ah
035 8.0 B
035 8.1 Jo
036 8.2 Ah
037 8.2 Ah
038 8.1 Ah
039 8.2 Ah
040 8.0 Jo
042 8.2 Jo
043 8.3 Lg

T Hya
085008
010 9.7 Ch
030 9.0 Br
032 9.0 Ch
033 9.0 B
036 8.7 L
043 8.6 Lg

T Cnc
085120
002 9.6 Ch
026 8.3 Pt
027 9.3 Ah
029 9.3 Ah
030 9.3 Ah
034 9.4 Ah
036 9.6 Ah
038 9.3 Ah
039 9.4 Ah
040 8.0 Jo
042 8.2 Jo
047 8.1 BL
050 8.3 BL
052 8.5 BL

T Pyx
090031
005 [u Bl

V UMa
090151
970 10.2 Nk
997 10.7 Nk
008 10.8 Nk
023 10.8 L

W Cnc
090425
030 13.8 Br
036 13.6 L

RX UMa
090567
023 11.5 L

RW Car
091868
983[13.3 Bl
987[12.2 Ht

RW Car
091868
005[13.3 Bl
007[12.8 Ht

Y Vel
092551
980 12.9 Ht
983 13.5 Bl
995 13.5 Bl
000 12.9 Ht
005 13.4 Bl
007 12.9 Ht

R Car
092963
980 5.3 Ht
983 5.6 Sm
983 5.5 Bl
984 5.5 En
987 5.6 Ht
995 5.6 Bl
997 6.0 Sm
000 6.3 Ht
005 6.3 Bl
007 6.3 Ht
007 6.3 En

X Hya
093014
985 11.4 Nz
998 11.1 Nz
002 11.2 Ch
008 10.8 Nz
026 9.0 Pt
032 9.5 Ch
033 9.3 B
035 9.4 Gy

Y Dra
093178
010 13.6 Ch
030 13.8 Br
035 14.0 B
036 13.4 L

R LMi
093934
009 12.5 Ch
026 11.9 Pt
030 11.9 Br
038 11.6 Ah

R Leo
094211
000 10.3 Ch
011 9.5 Ma
016 10.0 Ah
022 9.8 Ah
023 9.7 Ah
024 10.1 Sf
025 9.7 Jo
026 9.2 Pt
027 9.4 Ah
027 9.2 Ma
027 9.5 Fd

R Leo
094211
028 9.8 Wd
028 9.6 Ch
028 9.5 Ah
029 9.4 Ah
029 9.7 Wd
029 9.6 Jo
030 9.3 Bc
030 9.2 Ah
032 9.2 Ah
033 9.9 Sf
034 8.8 B
034 9.2 Ah
036 9.0 Ah
036 9.7 Jo
036 9.2 Wd
037 9.1 Ah
038 9.2 Ah
039 9.1 Ah
040 9.3 Sf
040 8.9 Ma
041 8.9 Fd
042 9.2 Wd
044 8.6 Fd
045 9.2 Wd
047 8.0 BL
050 8.5 BL
051 7.8 Ma
052 8.3 BL

Y Hya
094622
002 6.8 Ch
007 6.6 Ch
026 6.4 Pt

Z Vel
094953
980 12.1 Ht
983 11.6 Bl
983 12.1 Sm
987 12.1 Ht
995 12.1 Sm
995 12.0 Bl
000 12.5 Ht
005 12.6 Bl
006 12.8 Sm
007 12.8 Ht

V Leo
095421
002 10.0 Ch
026 9.4 Pt
026 9.8 Sf
030 9.5 Br
033 9.8 B
036 10.0 Sf
040 10.1 Sf

RR Car
095458
980 8.3 Ht
984 8.0 En

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

RR CAR
095458
987 8.3 Ht
000 8.3 Ht
007 8.0 Ht

RV CAR
103769
095563
000[13.1 Ht
005[13.1 Bl

RY LEO
095814
998 9.0 Kl
023 8.9 Kl
025 8.9 Kl
026 8.7 Kl
028 8.8 Kl
034 8.8 Kl

S CAR
100661
980 5.5 Ht
983 6.0 Sm
983 6.3 Bl
984 6.0 En
987 5.5 Ht
993 6.2 Sm
995 6.5 Bl
000 6.7 Ht
005 6.9 Bl
006 6.7 Sm
007 6.8 En
007 6.8 Ht

U UMA
100860
002 6.4 Ch

Z CAR
101058a
980 11.4 Ht
983 11.1 Sm
983 11.0 Bl
984 11.0 En
987 11.6 Ht
995 11.2 Sm
995 11.5 Bl
000 11.8 Ht
005 11.8 Bl
006 11.4 Sm
007 11.5 En
007 12.1 Ht

W VEL
101153
983 12.4 Bl
995 12.5 Bl
000 12.5 Ht
005 12.3 Bl
006 12.5 Sm
007 12.2 Ht

U HYA
103212
002 5.3 Ch
036 5.3 L

RZ CAR
103270
982 12.1 Ht
000 12.7 Ht

R UMA
103769
011 9.5 Ah
016 9.8 Ah
022 9.8 Ah
025 9.8 Jo
026 9.5 Pt
027 10.2 Ch
029 10.1 Ah
030 10.3 Ah
032 10.5 Ah
032 10.0 Jo
034 10.7 Ah
034 10.8 B
035 10.2 Br
036 10.5 Jo
036 10.5 Ah
038 10.8 Ah
044 11.0 Fd

V HYA
104620
983 6.8 Bl
995 7.4 Bl
002 7.5 Ch
005 7.4 Bl
007 7.6 Ch
026 6.8 Pt
036 6.9 L

RS HYA
104628
983 12.8 Bl
995 12.5 Bl
005 12.0 Bl

W LEO
104814
985 13.7 Nz
998 13.8 Nz
008 13.9 Nz
036 14.4 L

RS CAR
110361
983[12.3 Sm
998[12.3 Sm

S LEO
110506
027 13.3 Ch
036 14.2 L

RY CAR
111561
983[12.1 Sm
995[13.5 Bl
000[13.1 Ht
007[12.7 En

RS CEN
111661
980 11.2 Ht
983 10.3 Sm
983 10.6 Bl
987 10.3 Ht
995 9.2 Sm
995 9.7 Bl
000 9.2 Ht
005 8.9 Bl
006 8.4 Sm
007 8.6 En
007 8.6 Ht

X CEN
114441
982 10.8 Ht
983 10.8 Bl
995 11.1 Bl
000 11.7 Ht
005 12.0 Bl
007 11.5 Ht

AD CEN
114858
982 9.5 Ht
000 9.4 Ht
006 9.2 Sm
007 9.4 En
007 9.1 Ht

W CEN
115058
982 12.8 Ht
983 12.9 Bl
995 12.1 Bl
995 12.4 Sm
000 12.2 Ht
005 11.1 Bl
006 11.4 Sm
007 11.2 En
007 11.7 Ht

R COM
115919
028 12.2 Ch
030 11.6 Br
037 10.7 B
040 10.8 Pt

SU VIR
120012
028 9.2 Ch
040 8.8 Pt
040 9.5 Bw

T VIR
120905
026 10.9 L
040 11.7 Pt

R CRV
121418
985 7.9 Nz
998 8.1 Nz
008 8.9 Nz
026 9.8 L
040 11.0 Pt

SS VIR
122001
026 8.3 L

R CVN
122532
028 10.9 Ch
040 11.2 Pt

Y VIR
122803
985 12.2 Nz
998 12.9 Nz
008 13.4 Nz
028[12.0 Ch
036[14.4 L
040[12.0 Ma

U CEN
122854
983 12.8 Bl
995 12.4 Bl
000 12.5 Ht
005 11.8 Bl
007 12.3 Ht

T UMA
123160
027 12.0 Ch
027 13.1 Ma
037 12.7 B
040 12.7 Pt

R VIR
123307
027 9.1 Ma
028 9.0 Ch
040 10.4 Pt
040 9.9 Ma
044 10.0 Fd

RS UMA
123459
985 12.9 Nz
998 12.7 Nz
007 11.9 Ch
008 11.8 Nz
025 9.7 Jo
025 10.0 Bn
027 9.2 Ma
027 8.9 Fd
027 9.5 Ch
029 9.9 Wd
030 9.3 Bn
032 8.7 Jo
034 9.3 Bn
036 9.8 Wd
036 8.6 Jo
037 9.3 B
040 9.1 Pt
040 8.9 Ma
043 8.9 Bn
044 9.2 Fd
045 9.5 Wd
051 8.8 Ma

S UMA
123961
998 11.0 Kl
003 11.0 Kl
011 10.3 Ah
016 9.6 Ah
017 9.4 Lj
019 9.4 Lj
022 9.0 Ah
023 9.0 Kl
025 9.0 Kl
025 8.8 Jo
026 9.0 Kl
027 8.7 Fd
027 8.7 Ma
027 9.3 Ch
028 8.7 Lj
028 8.8 Wd
028 8.9 Kl
028 8.7 Ah
029 8.6 Ah
029 8.6 Wd
030 8.6 Ah
032 8.6 Ah
032 8.7 Jo
034 8.9 Kl
034 8.6 Ah
036 8.5 Ah
036 8.3 Jo
036 8.9 Wd
036 8.3 Lj
037 9.6 B
037 8.5 Ah
038 8.5 Ah
039 8.6 Ah
040 8.9 Pt
040 8.1 Ma
042 8.6 Wd
044 8.6 Fd
045 8.4 Wd
051 7.9 Ma

RU VIR
124204
026 9.1 L
040 10.4 Bw
041 10.3 Pt

U VIR
124606
026 11.6 L
027 10.2 Ah
028 10.2 Ah
029 10.3 Ah
030 10.3 Ah
032 10.3 Ah
033 10.2 Ch
034 10.2 Ah
035 10.0 Gy
036 10.2 Ah
038 10.2 Ah
039 10.1 Ah
041 10.0 Pt

U OCT
131283
007[13.2 Ht

V VIR
132202
984 5.3 Ht
000 5.9 Ht
005 6.6 Bl
007 5.8 Ht
026 6.7 L
026 7.0 Tf
031 6.6 Ch
036 7.3 Tf
041 7.1 Pt

S VIR
132706
031 11.8 Ch
041 11.3 Pt

RV CEN
133155
983 9.0 Bl
984 9.7 Ht
995 9.4 Bl
000 9.5 Ht
005 9.4 Bl
007 10.2 Ht

T UMI
133273
036 13.2 L

T CEN
133633
984 6.8 Ht
995 7.8 Bl
000 8.6 Ht
005 8.5 Bl
007 8.6 Ht

RT CEN
134236
984 9.3 Ht
995 9.2 Bl
000 9.6 Ht
005 9.3 Bl
007 9.5 Ht

R CVN
134440
027 10.2 Ah
028 10.2 Ah
029 10.3 Ah
030 10.3 Ah
032 10.3 Ah
033 10.2 Ch
034 10.2 Ah
035 10.0 Gy
036 10.2 Ah
038 10.2 Ah
039 10.1 Ah
041 10.0 Pt

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

RX CEN
134536
984 11.2 Ht
995 11.0 Bl
000 10.0 Ht
005 9.6 Bl
007 10.4 Ht
T APS
134677
982 10.8 Ht
983 10.8 Bl
995 11.1 Bl
995 12.3 Sm
000 12.0 Ht
005 12.0 Bl
006 12.7 Sm
007 12.5 Ht
RR VIR
135008
041 14.0 Pt
Z BOO
140113
035 14.2 L
Z VIR
140512
026 11.3 L
041 11.8 Pt
RU HYA
140528
984 11.0 Ht
000 11.7 Ht
005 11.5 Bl
R CEN
140959
983 7.9 Bl
984 7.6 Ht
995 8.2 Bl
997 8.3 Sm
000 8.1 Ht
005 8.6 Bl
007 8.5 Ht
U UMI
141567
017 12.4 Lj
028 12.0 Lj
029 11.4 Ah
030 11.3 Ah
034 11.2 Ah
036 11.2 Ah
036 11.5 Lj
038 11.1 Ah
041 11.5 Pt
S BOO
141954
026 8.9 L
029 8.6 Jo
031 9.0 Gb
033 9.0 Ch
036 9.0 Jo
040 9.1 Jo

S BOO
141954
041 9.0 Pt
RS VIR
142205
985 9.3 Nz
998 9.7 Nz
008 10.2 Nz
025 10.5 L
036 7.4 Tf
V BOO
142539a
016 7.9 Ah
022 8.0 Ah
027 8.2 Ah
027 8.4 Sf
028 8.2 Ah
029 8.3 Ah
029 8.0 Jo
030 8.2 Ah
031 8.2 Gb
032 8.1 Ah
033 8.1 Ch
036 8.2 Jo
036 8.7 Sf
036 8.3 Ah
038 8.2 Ah
039 8.2 Ah
040 8.3 Jo
041 8.5 Pt
044 9.0 Fd
R CAM
142584
030 10.5 Ah
033 11.4 Ch
034 10.5 Ah
038 10.5 Ah
R BOO
143227
016 9.5 Ah
017 9.8 Lj
019 9.8 Lj
027 10.3 Ah
028 10.6 Lj
029 10.2 Ah
030 10.4 Ah
032 10.7 Ah
033 10.7 Ch
034 10.7 Ah
036 11.4 Lj
039 11.1 Ah
041 11.5 Pt
V LIB
143417
035[13.5 L
U BOO
144918
016 11.8 Ch

Y LUP
145254
983 11.7 Bl
995 12.2 Bl
005 12.7 Bl
S APS
145971
983 10.9 Bl
984 10.9 Ht
995 10.9 Bl
997 10.4 Sm
000 11.0 Ht
005 10.8 Bl
006 10.8 Sm
007 10.8 Ht
T LIB
150519
015 12.8 Ch
Y LIB
150605
025 12.3 L
041 11.0 Pt
S LIB
151520
015 11.8 Ch
035 11.3 L
041 11.1 Pt
S SER
151714
035 13.5 L
044 12.0 Fd
S CRB
151731
041 10.3 Pt
044 11.2 Fd
RS LIB
151822
005 9.3 Bl
025 7.9 L
RU LIB
152714
015 9.7 Ch
025 9.4 L
041 8.4 Pt
R NOR
152819
984 10.9 Ht
000 11.9 Ht
005 11.2 Bl
X LIB
153020
005 11.8 Bl
W LIB
153215
005[13.4 Bl
015[13.4 Ch
S UMI
153378
017 11.1 Lj
019 11.1 Lj

S UMI
153378
025 11.7 Jo
028 11.4 Lj
029 11.0 Ah
030 11.1 Ah
032 11.7 Jo
033 10.5 Ch
034 11.2 Ah
036 11.3 Ah
036 11.5 Lj
038 11.4 Ah
040 11.5 Jo
041 10.9 Pt
U LIB
153620a
005 11.0 Bl
T NOR
153654
984 10.8 Ht
000 11.9 Ht
Z LIB
154020
005[12.7 Bl
R CRB
154428
008 6.0 L
010 5.9 L
014 6.0 Ch
016 6.1 Ah
017 6.1 Ch
017 6.1 Lj
019 6.1 Lj
022 6.0 L
025 6.0 L
025 6.2 Pt
026 6.2 Pt
026 5.9 Tf
027 6.1 Ah
028 6.0 Ah
028 6.1 Lj
029 6.0 Ah
030 6.0 Ah
030 6.0 L
031 6.1 Ch
031 6.0 Gb
032 6.0 Ah
034 6.1 Ah
035 6.0 L
035 5.9 Gy
035 6.1 Wd
036 6.2 Wd
036 6.2 Lj
036 6.0 Tf
036 6.2 Pt
036 6.1 Ah
037 6.2 Pt
038 6.1 Pt
038 6.0 Ah
039 6.0 Ah

R CRB
154428
040 6.2 Pt
041 6.1 Pt
044 5.9 Fd
045 6.1 Pt
Z CRB
154536
015 12.5 Ch
025 12.6 L
041 11.7 Pt
R SER
154615
014 7.9 Ch
041 8.8 Pt
V CRB
154639
015 10.0 Ch
041 9.5 Pt
R LIB
154715
015 13.0 Ch
RR LIB
155018
025 8.8 L
041 8.4 Pt
Z CRB
155229
015 12.4 Ch
035 13.0 L
RZ SCO
155823
041 11.4 Pt
Z SCO
160021
005 11.6 Bl
035 11.2 L
R HER
160118
041 8.4 Pt
044 9.0 Fd
U SER
160210
027[12.0 Ma
040 13.0 Ma
X SCO
160221a
005[13.0 Bl
SX HER
160325
025 7.9 L
035 8.3 L
038 8.0 Pt
040 8.2 Pt
041 8.5 Pt
W SCO
160519
005[13.8 Bl

RU HER
160625a
014 11.3 Ch
035 11.9 L
041 11.9 Pt
R SCO
161122a
985[14.3 Nz
005[13.2 Bl
041 12.6 Pt
S SCO
161122b
985 11.1 Nz
998 11.5 Nz
005 12.5 Bl
008 12.8 Nz
W CRB
161138
041 10.8 Pt
W OPH
161607
035 13.2 L
V OPH
162112
025 7.4 L
026 7.4 Tf
036 8.1 Tf
041 7.2 Pt
U HER
162119
030 10.0 Ah
034 9.8 Ah
038 10.0 Ah
039 10.2 Ah
041 10.2 Pt
044 10.2 Fd
Y SCO
162319
035[13.5 L
SS HER
162807
017 10.0 Ch
025 11.2 L
041 12.8 Pt
T OPH
162815
018 13.1 Ch
035 12.4 L
S OPH
162816
005[13.2 Bl
016[13.1 Ch
035 14.2 L
W HER
163137
014 9.0 Ch
041 9.8 Pt
044 9.6 Fd

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1930.

J.D.	Est.	Obs.
R DRA		
163266		
017	10.3	Lj
019	10.0	Lj
027	9.6	Fd
027	9.7	Ma
027	9.4	Ah
028	9.3	Lj
029	9.1	Jo
029	9.2	Ah
030	9.1	Ah
032	8.9	Ah
034	8.9	Ah
035	8.7	Gy
035	8.5	Jo
036	8.8	Lj
036	8.9	Ah
038	8.6	Ah
039	8.4	Ah
040	8.3	Jo
040	8.1	Ma
041	8.0	Pt
041	8.0	Fd
044	8.1	Fd
051	8.1	Ma
RR OPH		
164310		
985	10.9	Nz
998	11.6	Nz
008	11.9	Nz
035	13.5	L
S HER		
164715		
016	12.3	Ch
041	12.0	Pt
RS SCO		
164844		
005	11.8	Bl
RR SCO		
165030a		
005	11.5	Bl
SS OPH		
165202		
041	12.8	Pt
RV HER		
165631		
015	12.2	Ch
025	10.8	L
RT SCO		
165636		
005	[14.0	Bl
— DRA		
165752		
035	14.5	L
R OPH		
170215		
014	9.7	Ch
035	10.6	L

J.D.	Est.	Obs.
RT HER		
170627		
008	10.1	L
015	10.8	Ch
035	10.7	L
041	11.3	Pt
RW SCO		
170833		
005	[12.6	Bl
Z OPH		
171401		
041	12.5	Pt
RS HER		
171723		
041	8.1	Pt
S OCT		
172486		
982	8.3	Ht
983	8.3	Bl
993	8.8	Ht
994	8.9	Bl
995	8.6	Sm
000	8.8	Ht
001	8.7	En
004	9.1	Bl
006	8.9	Sm
007	9.1	Ht
RU OPH		
172809		
015	12.3	Ch
035	11.3	L
041	11.1	Pt
RU SCO		
173543		
005	11.4	Bl
SV SCO		
174135		
005	9.8	Bl
W PAV		
174162		
983	9.7	Bl
995	9.9	Bl
004	10.9	Bl
RS OPH		
174406		
041	11.3	Pt
RT OPH		
175111		
016	9.4	Ch
035	9.8	L
041	10.1	Pt
T DRA		
175458a		
031	12.2	Ch
UY DRA		
175458b		
031	11.0	Ch
RY HER		
175519		
014	12.2	Ch

J.D.	Est.	Obs.
RY HER		
175519		
031	13.5	Ch
035	13.6	L
041	13.4	Pt
V DRA		
175654		
031	11.5	Ch
035	11.2	L
T HER		
180531		
026	8.1	Tf
030	8.1	Ah
031	8.2	Ch
034	8.7	Ah
035	8.3	L
036	8.8	Tf
038	9.0	Ah
039	9.1	Ah
041	8.8	Pt
044	9.0	Fd
W DRA		
180565		
035	[14.1	L
X DRA		
180666		
035	[14.0	L
NOV OPH		
180911		
041	[13.0	Pt
TV HER		
181031		
035	10.6	L
RY OPH		
181103		
041	13.0	Pt
W LYR		
181136		
030	9.8	Ah
035	10.0	L
038	10.2	Ah
039	10.1	Ah
041	10.6	Pt
RV SGR		
182133		
005	12.8	Bl
SV HER		
182224		
035	10.7	L
T SER		
182306		
017	[12.2	Ch
SV DRA		
183149		
027	11.4	Ma
035	11.1	L
040	10.3	Ma
RZ HER		
183225		
035	11.8	L

J.D.	Est.	Obs.
X OPH		
183308		
937	8.3	Nk
943	8.4	Nk
035	8.6	L
041	8.5	Pt
RS DRA		
184074		
892	10.3	BR
897	10.1	BR
905	9.9	BR
921	9.1	BR
922	9.0	BR
927	9.0	BR
936	9.0	BR
939	9.0	BR
963	9.1	BR
964	9.0	BR
RY LYR		
184134		
031	[12.2	Ch
036	[13.2	L
R SCT		
184205		
008	6.3	L
014	5.8	Ch
017	5.8	Lj
019	5.4	Lj
020	5.4	Lj
022	5.0	L
023	5.3	Tf
028	5.4	Lj
030	5.4	Ch
035	5.0	L
036	5.0	Lj
036	5.1	Tf
RX LYR		
185032		
030	[13.0	Ch
035	14.5	L
S CRA		
185437a		
005	11.7	Bl
ST SGR		
185512a		
035	[14.0	L
R CRA		
185537a		
005	[12.5	Bl
T CRA		
185537b		
005	[12.5	Bl
Z LYR		
185634		
032	[12.3	Ch
036	[14.0	L
RT LYR		
185737		
030	10.2	Ch
036	10.5	L

J.D.	Est.	Obs.
R AQL		
190108		
017	5.4	Ch
045	6.4	Pt
V LYR		
190529a		
032	[12.9	Ch
RX SGR		
190818		
035	12.4	L
RW SGR		
190819a		
035	9.6	L
TY AQL		
190907		
045	10.0	Pt
S LYR		
190925		
032	[13.5	Ch
036	[14.4	L
X LYR		
190926		
045	8.7	Pt
RS LYR		
190933a		
032	12.2	Ch
036	11.8	L
045	11.5	Pt
RU LYR		
190941		
036	12.8	L
045	13.2	Pt
U DRA		
190967		
036	12.6	L
045	13.0	Pt
W AQL		
191007		
045	12.6	Pt
T SGR		
191017		
035	10.5	L
045	10.0	Pt
R SGR		
191019		
035	12.2	L
045	11.2	Pt
RY SGR		
191033		
005	6.2	Bl
035	6.6	L
041	6.4	Pt
045	6.5	Pt
063	8.0	Pt
TZ CYG		
191350		
045	10.3	Pt
U LYR		
191637		
045	10.5	Pt

J.D.	Est.	Obs.
AF CYG		
192743		
016	7.2	Ah
022	7.4	Ah
027	7.5	Ah
029	7.4	Ah
030	7.3	Ah
032	7.5	Ah
034	7.5	Ah
038	7.4	Ah
039	7.5	Ah
TY CYG		
192928		
008	12.5	L
030	12.2	Ch
036	12.0	L
045	11.9	Pt
RT AQL		
193311		
008	13.2	L
030	13.6	Ch
R CYG		
193449		
030	14.0	Ch
045	13.2	Pt
RV AQL		
193509		
036	9.2	L
045	9.9	Pt
T PAV		
193072		
980	9.0	Ht
983	8.9	Bl
987	9.0	Ht
995	9.1	Bl
000	8.7	Ht
002	9.2	Bl
RT CYG		
194048		
016	9.7	Ah
022	10.5	Ah
027	10.8	Ah
030	11.5	Ch
044	9.0	Fd
045	11.3	Pt
TU CYG		
194348		
030	13.0	Ch
036	12.6	L
045	11.5	Pt
X AQL		
194604		
036	[13.4	L
χ CYG		
194632		
030	[13.6	Ch
045	13.1	Pt
RU SGR		
195142		
005	[11.6	Bl

Variable Star Observations Received During March, 1930.

J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs. J.D.Est.Obs.

RR Aql
195202
036 12.2 L
Nov Cyg
195553
023[12.2 Pt
030[13.2 Ch
041[12.2 Pt
045[12.2 Pt
Z Cyg
195849
030 11.7 Ch
036 11.1 L
045 10.9 Pt
S Tel
195855
004[12.0 Bl
SY Aql
200212
036 12.0 L
045 11.8 Pt
BU Cyg
200250
017 11.1 Lj
028 11.5 Lj
036[11.8 Lj
S Cyg
200357
030 10.5 Ch
036 10.4 L
045 10.7 Pt
S Aql
200715a
045 11.4 Pt
RW Aql
200715b
045 9.4 Pt
RU Aql
200812
036 11.8 L
Z Aql
200906
045 11.9 Pt
RS Cyg
200938
014 7.2 Ch
022 7.5 L
030 7.3 Ch
036 7.5 L
044 7.4 Fd
045 7.2 Ch
R Del
201008
036 9.8 L
045 9.0 Pt
SX Cyg
201130
022 8.6 L
045 9.8 Pt

WX Cyg
201437b
022 11.2 L
045 9.5 Pt
U Cyg
201647
962 8.1 Nk
014 10.4 Ch
044 10.4 Fd
045 9.2 Pt
Z Del
202817
036[13.1 L
ST Cyg
202954
036 12.1 L
045 12.3 Pt
V Vul
203226
045 8.5 Pt
Y Del
203611
036[13.6 L
S Del
203816
918 9.1 Nk
937 9.7 Nk
043 10.2 Nk
949 10.2 Nk
036 11.1 Lj
045 11.5 Pt
V Cyg
203847
036 12.4 L
045 13.5 Pt
T Del
204016
036 9.5 L
045 9.5 Pt
V Del
204318
036[13.1 L
RZ Cyg
204846
045 12.1 Pt
S Ind
204954
980[13.1 Ht
005[12.0 Bl
X Del
205017
036 9.9 L
R Vul
205923a
045 8.4 Pt
R Equ
210812
036 10.2 L

T Cep
210868
917 7.0 Nk
000 7.6 Ch
011 7.7 Ah
016 7.7 Ah
021 8.0 Ah
022 8.0 Ah
023 8.1 Ah
023 7.9 Pt
025 7.9 Jo
027 8.2 Ah
028 8.2 Ah
029 8.4 Ah
030 8.2 Ah
032 8.4 Ah
032 7.8 Jo
034 8.4 Ah
035 8.4 Gy
036 8.4 Ah
037 8.5 Ah
038 8.6 Ah
039 8.6 Ah
040 8.0 Jo
041 8.6 Fd
044 8.4 Fd
Y Pav
211570
980 6.4 Ht
987 5.9 Ht
000 6.4 Ht
007 6.1 Ht
X Peg
211614
036[12.0 L
S Mic
212030
979[12.4 En
W Cyg
213244
022 5.8 L
036 5.7 L
S Cep
213678
023 10.0 Pt
RU Cyg
213753
023 7.8 Pt
RV Cyg
213937
045 6.2 Pt
R Gru
214247
979 12.4 En
980 12.4 Ht
983 11.8 Bl
987 12.2 Ht
995 11.4 Bl
997 11.6 Sm
999 11.0 En

R Gru
214247
005 9.0 Bl
RZ Peg
220133b
892 11.7 BR
897 11.7 BR
922 11.5 BR
936 11.2 BR
939 11.1 BR
961 9.7 BR
963 9.7 BR
964 9.6 BR
984 9.5 BR
036 8.6 L
045 9.8 Pt
T Gru
221938
979 8.8 En
983 9.4 Sm
S Gru
221048
980[12.8 Ht
997[11.4 Sm
998[12.8 En
S Lac
222439
028 11.6 L
045 12.4 Pt
R Ind
222867
980 10.5 Ht
983 10.6 Bl
987 10.0 Ht
995 9.7 Bl
000 9.4 Ht
002 9.4 Bl
007 9.4 Ht
T Tuc
223462
979 10.9 En
980 11.0 Ht
987 11.3 Ht
995 11.8 Sm
000 12.3 En
000 11.9 Ht
007 12.3 Ht
R Lac
223841
005 12.5 Ch
VY And
225745
892 10.1 BR
896 10.1 BR
900 10.1 BR
905 10.2 BR
RW Peg
225914
005 13.3 Ch
007 14.5 Nz

V Cas
230759
011 9.0 Ah
016 8.7 Ah
022 8.3 Ah
023 8.2 Ah
023 8.1 Pt
027 8.2 Sf
027 8.0 Ah
028 8.0 Ah
029 8.0 Ah
030 7.9 Ah
032 7.9 Ah
034 7.9 Ah
034 8.2 B
036 7.8 Ah
037 7.9 Ah
038 7.9 Ah
039 7.8 Ah
040 8.0 Sf
041 7.6 Fd
W Peg
231425
006 12.6 Ch
028 11.8 L
S Peg
231508
023 11.0 Pt
RY Cep
231878
000 9.3 Ch
V Phe
232746
980 12.2 Ht
983 12.7 Sm
987 12.7 Ht
000 12.7 Ht
Z And
232848
023 9.8 Pt
ST And
233335
000 10.6 Ch
017 10.2 Lj
019 10.1 Lj
023 9.9 Pt
028 10.0 Lj
029 9.5 B
033 10.0 Lj
036 9.9 Lj
R Aqr
233815
980 8.6 Ht
983 8.9 Bl
987 8.3 Ht
995 8.9 Bl
001 8.5 Ch
005 8.9 Bl

Z Cas
233956
001 10.9 Ch
036 11.9 L
RR Cas
235053
024 13.0 Bn
034 12.0 Bn
037 11.8 B
V Cet
235209
001 10.8 Ch
005 9.5 Bl
R Tuc
235265
980 10.4 Ht
987 10.0 Ht
995 9.1 Sm
000 8.7 En
000 9.7 Ht
006 9.1 Sm
007 9.5 Ht
R Cas
235350
011 6.6 Ah
016 6.8 Ah
021 7.0 Ah
022 6.9 Ah
023 7.1 Ah
027 7.2 Ah
028 7.2 Ah
028 7.1 Ch
029 7.3 Ah
030 7.4 Ah
032 7.5 Ah
034 7.4 Ah
036 7.6 Ah
037 7.7 Ah
037 7.6 B
038 7.6 Ah
039 7.8 Ah
041 7.7 Fd
Z Peg
235525
005 12.6 Ch
017 12.4 Lj
023 11.5 Pt
033 11.8 Lj
036 11.5 Lj
036 11.1 L
W Cet
235715
006 12.0 Ch
Y Cas
235855
005 10.3 Ch
036 11.0 L
037 10.5 B

Variable Star Observations Received During March, 1930.

Rapidly Varying Irregular Variables.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
005840 RX Andromedae—						
	6023.5	11.7	Pt	6030.6	12.8	Br
	6026.5	12.8	Pt	6034.6	11.0	Br
	6027.5	[12.4	Pt	6035.6	11.4	Br
	6028.6	13.3	Br	6036.5	11.2	Pt
	6029.6	12.6	Br	6040.5	[12.6	Pt
060547 SS Aurigae—						
	5979.1	12.5	Nz	6028.6	11.2	Br
	5980.1	13.4	Nz	6029.5	11.0	Pt
	5982.1	14.2	Nz	6029.6	10.8	Bw
	5985.4	14.3	Nz	6029.6	11.3	Br
	5989.1	[13.2	Nz	6030.3	11.2	L
	5995.1	14.5	Nz	6030.6	11.5	Br
	6001.1	14.1	Nz	6031.7	11.8	Pt
	6003.6	[13.7	Hs	6033.2	11.6	Ch
	6004.2	14.8	Nz	6034.6	13.5	Pt
	6006.2	14.9	Nz	6034.6	14.3	Br
	6008.7	[12.4	L	6035.2	13.9	L
	6010.4	14.8	L	6035.6	14.3	Br
	6015.3	[13.3	L	6036.6	[13.3	L
	6021.6	[12.0	Pt	6037.7	[13.9	Br
	6022.5	[12.4	Pt	6038.9	[12.6	Pt
	6023.3	[13.9	L	6040.7	[13.9	Br
	6025.7	[12.6	Bw	6041.5	[12.6	Pt
	6026.2	[13.3	Ch	6042.8	[13.8	Lg
	6027.5	[12.6	Pt	6043.6	[13.8	Lg
	6028.3	11.9	L	6045.6	[12.6	Bw
	6028.5	11.0	Pt			
074922 U Geminorum—						
	5980.1	13.6	Nz	6015.3	13.9	L
	5985.4	13.8	Nz	6021.5	[11.2	Pt
	5989.1	[13.3	Nz	6022.5	[11.2	Pt
	5998.4	9.4	Nz	6023.5	[12.3	Pt
	5999.1	9.5	Nz	6025.4	14.0	L
	6000.1	9.2	Ch	6026.5	[12.4	Pt
	6001.2	9.3	Nz	6027.5	[12.4	Pt
	6004.2	10.1	Nz	6028.1	13.8	Ch
	6005.1	9.7	Ch	6029.6	14.0	Br
	6006.2	10.9	Nz	6030.6	[13.9	Br
	6008.1	12.7	Ch	6031.7	[11.7	Pt
	6008.4	12.8	Nz	5034.6	14.2	Br
	6008.7	12.8	L	6035.6	14.2	Br
	6010.4	13.4	L	6036.3	13.8	L
074922 U Geminorum—						
	6036.5	14.1	L	6038.9	[13.3	Pt
	6036.5	[12.4	Pt	6040.7	[12.4	Ma
	6037.7	[13.7	Br	6043.6	13.9	Lg
081473 Z Camelopardalis—						
	6002.2	11.6	Ch	6029.7	11.3	Br
	6008.7	10.9	L	6030.5	11.0	L
	6010.4	11.4	L	6030.6	11.2	Br
	6015.3	11.9	L	6032.1	10.8	Ch
	6022.7	12.0	L	6034.6	12.3	Br
	6023.4	12.1	L	6035.2	12.3	L
	6025.4	12.1	L	6035.6	11.7	Br
	6026.7	12.1	L	6036.3	12.1	L
	6028.3	11.8	L	6036.6	11.7	L
	6028.7	11.3	Br	6040.7	11.4	Br
094512 X Leonis—						
	6008.7	12.4	L	6028.3	12.1	L
	6010.4	[13.8	L	6030.5	12.1	L
	6025.4	[14.2	L	6030.7	12.3	Br
	6026.7	12.3	L	6035.5	[14.2	L
202946 SZ Cygni—						
	6021.5	9.2	Pt	6038.9	9.0	Pt
	6023.5	9.0	Pt	6041.9	9.0	Pt
	6026.5	9.2	Pt	6045.9	9.3	Pt
	6027.5	9.2	Pt			
213843 SS Cygni—						
	5917.0	11.6	Nk	6026.3	10.2	Kl
	5943.9	11.6	Nk	6026.5	10.5	Pt
	5951.0	11.9	Nk	6027.3	10.3	Ah
	5995.9	11.7	Nk	6027.5	11.5	Pt
	5996.9	11.7	Nk	6028.2	11.4	L
	5998.3	11.0	Kl	6028.3	10.8	Kl
	6000.1	11.5	Ch	6028.7	10.9	Lj
	6006.0	11.5	Ch	6029.3	11.2	Ah
	6017.2	11.8	Lj	6030.3	11.8	Ah
	6019.7	8.8	Lj	6032.3	11.8	Ah
	6020.7	8.6	Lj	6034.3	11.8	Ah
	6022.2	8.8	Ah	6034.3	10.9	Kl
	6022.7	8.9	L	6036.5	11.7	Pt
	6023.3	8.9	Ah	6036.6	12.0	Lj
	6023.3	8.7	Kl	6036.7	12.0	L
	6023.5	9.2	Pt	6040.9	11.0	Ma
	6025.2	10.1	L	6041.9	11.7	Pt
	6025.3	9.4	Kl	6045.9	11.7	Pt

Monthly Summary for March, 1930.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	46	365	Buckstaff	Bc	3	5
Allen, P. R.	Al	6	6	Chandra	Ch	164	189
Baldwin	Bl	86	182	Ensor	En	33	47
Beyer	BR	4	26	Ford	Fd	24	24
Bigelow	Bw	8	10	Gaebler	Gb	4	4
Boutell	BL	10	74	Gregory	Gy	7	7
Bouton	B	70	70	Hawes	Hs	3	5
Brocchi	Br	26	51	Houghton	Ht	58	174
Brown, A. N.	Bn	4	12	Jones	Jo	23	65

MONTHLY SUMMARY FOR MARCH, 1930.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Kohl	Kl	3	19	Nizamiah Obs.	Nz	24	83
Kusel	Ku	1	1	Peltier	Pt	178	259
Lacchini	L	160	225	Schoechert	Sr	1	1
Leiner	Lj	13	50	Smith, F. W.	Sf	8	19
Logan	Lg	7	9	Smith, W. H.	Sm	45	74
Marsh	Ma	17	36	Taffara	Tf	9	15
Millard	Md	3	3	Webb	Wd	6	24
Nakamura	Nk	13	39				
				Totals	33	396	2174

first contribution of observations by Messrs. Kusel and Schoechert who are working under the guidance of Mr. Gaebler.

Due to the diligence of Mr. Peltier RY Sagittarii has again been caught on the drop to minimum. The star should demand the closest attention of our observers, especially those located in the southern hemisphere.

Attention is again called to the meeting of the Association to be held at Nantucket, Mass., on June 14, at the kind invitation of Miss Harwood. At that time of the year Nantucket should be at its best and a successful meeting is assured all who attend.

LEON CAMPBELL, Recording Secretary.

April 10, 1930.

METEOR NOTES

By CHARLES P. OLIVIER.

The first three months of 1930 certainly have been very poor ones for meteors. The rates on many nights have been dishearteningly low, and it has taken real industry and enthusiasm for an observer to hold himself to the task of watching for the rare meteors that did appear. However, at least, we have the information that this particular part of space recently traversed by the earth seems sparsely filled with meteors. Partly balancing this we have to date separate reports of 29 brilliant fireballs, and belated reports of 8 more seen in 1928 and 1929 which came in too late for our annual report.

In the early hours of this morning (April 21) the writer observed for Lyrids from 12:45 to 13:25, in a fairly clear sky, and saw two. Then turning to his regular work with the 18-inch refractor, he was stopped by clouds a half hour later. Going outside his attention was caught by a gorgeous meteor train about 10° west of Polaris. Despite the haze there, the train showed as a wide rosy band, perfectly straight and almost vertical. The bright part was about 6° long, tapering off 2° or so at either end. The train did not move sideways, but faded out gradually, aided doubtless by increasing haze. The writer saw it at 2:00 A.M., but how long before the meteor had passed is problematical. It was the most brilliant train he has ever seen. It is probable that the meteor ended over Susquehana County, Pennsylvania, and observations from eye-witnesses are urgently requested. This prediction is made on the assumption that the lower end of the long-enduring train was about 50 miles high.

As it is necessary to send off these notes at once, we cannot wait for the arrival of other observations on the Lyrids. The Aquarids of early May furnish

the only prominent shower expected until late July. They will not be interfered with by moonlight and, as they are connected with Halley's Comet, observations are always desirable.

Work on the heights and orbits of several fireballs is now under way here and the results should be ready for publication in the near future. Also we desire to issue a new membership list. Will persons who have sent in no recent observations and are behind in their dues kindly notify us of their intentions as to future membership in the A.M.S.

D. F. WAUGH, TOKYO, JAPAN.

Date		Began	Ended	Total	Meteors	F	Rate	Cor. Rate
1930 Feb.	3	10:55	12:41	106	7	0.9	4.0	4.4
	4	10:50	12:00	70	2	0.6	2.3	3.8
	24	12:45	14:18	93	9	0.8	5.8	7.2
	25	9:45	11:25	100	2	0.6	3.3	5.5
Mar.	21	11:52	12:54	62	2	1.0	1.9	1.9
	22	11:05	13:45	160	8	1.0	3.0	3.0
	23	11:50	14:02	132	9	1.0	4.1	4.1
	29	12:30	14:30	120	7	0.8	3.5	4.4

R. H. WILSON, JR., DUNCANNON, PENNSYLVANIA.

Date		Began	Ended	Total	Meteors	F	Rate	Cor. Rate
1930 April	2	9:00	10:00	60	5	1.0	5.0	5.0
	4	9:35	10:05	30	1	0.8	2.0	2.5
	5	9:30	10:00	30	0	0.3	0.	0.

B. C. DARLING, LANSING, MICHIGAN.

Date		Began	Ended	Total	Meteors	F	Rate	Cor. Rate
1930 Jan.	2	13:50	15:45	90	7*	0.4	4.7	11.8
	3	9:28	10:04	36	0	1.0	0.	0.
	28	8:40	9:20	40	1	1.0	1.5	1.5
	29	8:30	10:16	70	5	1.0	4.3	4.3
Feb.	19	8:45	9:45	60	0	0.7	0.	0.
	23	9:00	10:00	60	0	0.9	0.	0.
Mar.	8	8:02	9:32	60	0	1.0	0.	0.
	13			33	0	0.4	0.	0.
	14			38	0	0.4	0.	0.
	16	9:04	9:40	36	1	0.8	1.7	2.1
	19	9:00	10:00	60	1	1.0	1.0	1.0
	20	9:00	10:00	60	3	1.0	3.0	3.0
	21	9:35	11:05	60	3	1.0	3.0	3.0
	22	11:30	14:25	74	7	1.0		

*Three Quadrantids.

C. P. OLIVIER, FLOWER OBSERVATORY, PENNSYLVANIA.

Date		Began	Ended	Total	Lyrids	F	Rate	Cor. Rate
1930 April	20	12:45	13:25	40	2	0.6	3.0	5.0

GORDEN RIDLEY, ALAMEDA, CALIFORNIA.

February and March, 10 meteors, sent in through B. C. Darling; 4 were fireballs.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1930 April 21.

The Paragould Meteor and Meteorites.

(Second Note.)

Observers of this meteor have been interviewed in Poplar Bluff, Missouri; Corning, Arkansas; Paragould, and points nearby, Arkansas; and Memphis, Tennessee. Miss Jessica M. Young, of the Department of Astronomy of Wash-

ington University, has kindly offered to interview several who saw it from St. Louis and vicinity. The positions should give a reasonably good determination of the path of the meteor through the atmosphere. It was bright enough that persons in St. Louis mistook it for an airplane going down in flames.

The detonations were pronounced as far north as Poplar Bluff, Missouri, and as far east as Covington and Ripley in Tennessee. In the immediate vicinity of Paragould, nearly all sleepers were awakened, and stock on farms was stampeded.

A stone weighing 80 pounds, and pronounced a genuine meteorite by S. H. Perry, was recovered by a farmer who noticed freshly thrown earth when he was going for his horses in the morning. The report of those who dug out this stone was that it had come from the southwest. A neighbor reported that he had seen the meteor travelling northward, and the first report received on the rumble following the detonation was that it had rolled away toward the southwest.

Later reports, evidently authentic observations, and from St. Louis to Memphis, agree that the meteor was travelling from northeast to southwest, and persons in the vicinity of Paragould who were outdoors agree that the meteor came from the northeast, and the rumble following the detonations rolled toward the northeast. The first report on the roll was from a resident of Paragould who was indoors, and he may have heard the echo from a nearby building entering his window.

The meteor fell at about 4:05 A.M., February 17, Civil Time, and the first stone was recovered the same day. On March 16, a second and larger hole was found, and after much labor a stone said to weigh 820 pounds was raised from a depth of 8 feet. This stone appears to be identical with the first, and an authentic meteorite. It is not as pitted as most meteorites, and in crust and broken surface it resembles somewhat the large meteorite of the Farmington fall. A preliminary chemical analysis by Dr. K. W. Ray was made.

If the weight is correct, this is a new record for meteorites remaining intact, and for which the date of fall is known.

C. C. WYLIE.

University of Iowa, April 16, 1930.

COMET NOTES

By G. VAN BIESBROECK.

The two comets BEYER (1930 *b*) and WILK (1930 *c*) have now reached high northern declinations and can be seen for several hours; the first one after sunset, the second before sunrise.

The circumstances of the discovery of the comet 1930 *b* are described by M. Beyer in Circular No. 11 of the *Astronomische Nachrichten*. On 1930 Feb. 26 he had exposed a plate for 40 min. with the 6-inch astrograph ($f = \frac{1}{3}$) of the Gummelt Observatory near Hamburg (Germany). On this he found on March 4 a diffuse trail 0.8 long in $6^h\,6^m$ and $+25°\,25'$ (1855). He suspected it to be due to a comet moving in a NNW direction. Not until March 11 did the weather allow him a further examination of the sky. An exposure of 15 minutes, partly fogged by the moonlight showed a faint diffuse object in the region extrapolated with the motion given by the first plate. The final check was obtained March 12 when, in spite of the bright moon, the comet was seen directly in the expected position by means of a refractor of $4\frac{1}{2}$ inches aperture, but on account of the moon it was

difficult to estimate the brightness, which the discoverer called $10^{M}.5$. This explains why the announcement came nearly at the time of the full moon.

The comet has been followed by various observers during the last month. Well situated in the evening sky in the constellation the Lynx, it could be seen in a telescope of medium size as a round coma of about 1′ in diameter, of magnitude 11.

The following ephemeris, computed by J. P. Moeller from the elements by E. C. Bower and Miss Moore (see p. 241), shows the course of the comet. The brightness, assumed to correspond to magnitude 11 on April 14, is slowly decreasing but the comet will remain visible for several months.

EPHEMERIS OF BEYER'S COMET *(Circ. 269 of the Intern. Union).*

0^{h} U.T. 1930	α h m	δ ° ′	Mg.
April 14	6 23.1	+44 12	11.0
18	28.0	45 19	
22	33.5	46 22	11.1
26	39.5	47 22	
30	46.0	48 20	11.2
May 4	6 53.0	49 15	
8	7 0.6	50 7	11.3
12	8.7	50 56	
16	17.3	51 42	11.3
20	26.4	52 26	
24	7 0.6	+53 7	11.4

On April 22, the date of the closest approach to the sun, the writer photographed the comet with the 24-inch reflector; an exposure of 20 minutes showed a fairly sharp nucleus surrounded by a round coma less than 1′ in diameter. There was no trace of a tail, nor any dissymmetry in the coma. The correction of the ephemeris for that date was: $-0^{m}.4$ and −6′.

WILK'S COMET (1930 *c*) has now become a morning object. It is much brighter and more interesting than Beyer's. It reached naked eye visibility in the latter part of March near the time of the perihelion passage. The estimations of magnitude by various observers range between 5 to 6 at that time. Since then the brightness has decreased. When last observed here on April 23 the magnitude was 7.5. Figure 1 shows the appearance of the comet on that morning, from a

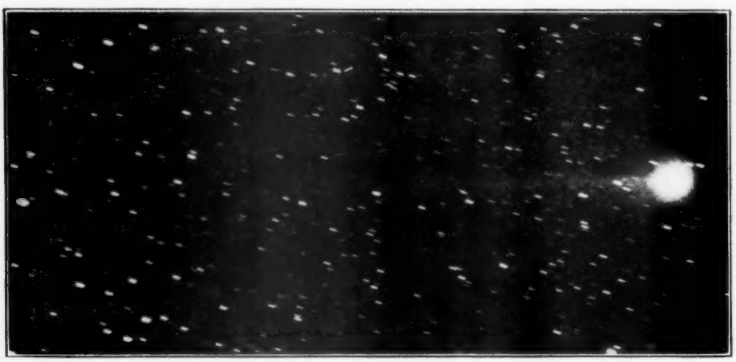


FIGURE 1.
WILK'S COMET (1930 *c*) ON APRIL 23.
(Scale 47″ to a millimeter.)

plate exposed for 15 minutes with the 24-inch reflector. The round coma has a diameter of 3′; in position angle 300° there is a tail which can be traced over 1¼ degrees on the plate; it is made up of a narrow emission of material gradually spreading in a bundle of streamers; the coma is a little sharper defined on the south side; toward the north it diffuses out farther from the nucleus which gives a dissymmetrical appearance to the head. The following ephemeris computed at Berkeley by F. L. Whipple and Miss Ph. Hayford is based on new parabolic elements representing the measures on March 23, 25, and 27 (*Harvard Announcement Card* 122):

1930 U.T.		α h m s	δ ° ′	Br.
April	18	23 42 27	+43 12.3	1.00
	22	23 20 58	44 17.2	
	26	22 58 55	44 59.7	
	30	22 36 00	45 22.9	
May	4	22 11 54	45 27.2	
	8	21 46 20	45 10.3	0.63
	12	21 19 08	44 28.1	
	16	20 50 26	43 15.4	
	20	20 20 39	41 26.1	
	24	19 50 30	38 56.2	
	28	19 20 55	35 44.9	
June	1	18 52 52	+31 56.7	0.41

On April 23 the correction was: +13ˢ and −9′.

It will be seen that the comet will be very well placed for observations in the second half of the night but will gradually lose its brightness. It is now in the constellation the Lizard; in the beginning of May it passes into the Swan, which it will cross diametrically; the end of May will find it entering the constellation of Lyra.

According to A. C. D. Crommelin Wilk's Comet is probably identical with the long expected De Vico's Comet 1846 IV for which a period of 76 years had been computed.

The elements published so far compare as follows:

	Comet Wilk 1930 *c*			Comet 1846 IV
Computer	Banachiewicz	Whipple (1)	Moeller	Hepperger
T	Mar. 28.962	Mar. 28.83	Mar. 26.746	.....
ω	47° 4′	47° 54′	35° 42′	12° 53′
☊	89 39	90 31	89 2	77 33
i	68 58	64 27	81 25	85 6
q	0.468	0.477	0.522	0.664
Dates Used	Mar. 21, 23, 25	Mar. 22, 23, 25	Mar. 22, 23, 24	.....
Equinox	1930.0	1930.0	1930.0	1846.0

While the orbits resemble in a general way the conclusion of identity seems premature. With an inclination of 85° the perturbations of De Vico's Comet can hardly have been as large as the identity would require, especially in the longitude of the perihelion and the perihelion distance. More accurate computations will soon settle the question. On a plate exposed at Berlin 1929 Dec. 20, three months before the discovery by Wilk, an image of the comet has subsequently been found and measured by R. Prager:

1929 Dec. 20 at $17^h 6^m$ U.T. $\alpha = 18^h 8^m 10^s.3$, $\delta = +36° 23'.0$.

This early position will greatly help in reducing the uncertainty of the elements.

The only other comet that is now under observation is Stearn's 1927 *d* but it is now extremely faint. It was photographed here April 22 and 23 quite close

to the ephemeris position as a small round nebulosity of magnitude 17. This extends the period of visibility to 37 months!

Williams Bay, Wisconsin, April 24, 1930.

NOTES FROM AMATEURS

Planetary Progression.

The discussion of Bode's "law," prompted by the discovery of Neptune, which first departed notably from it, will have its counterpart at the present time in efforts to educe some new "law" of planetary distances which will admit the newly discovered planet, which also ignores the law of Bode.

An examination of a table or diagram of the solar system exhibits a sort of progression of the planetary distances, which, however evident, resists the attempt to express precisely. It is profitable to find such an expression; since we perceive the progression, we desire a formulation of it.

The following representation, regardless of the significance it may (or may not) have, is a simple and accurate way of exhibiting the planetary relations.

Draw a circle of unit radius, and in it two perpendicular radii; produce one of them outside the circle, and beginning at the circumference, lay off on this radius four segments of 1½, 2½, 3½, and 4½ units. From the extremity of the other radius as a center, we draw five circles through the five points on the other radius (excluding the center).* These are the circles shown in the figure.

From this set of five radii, we construct a minor set and a major set which are the original set respectively divided by and multiplied by the same quantity. We choose this quantity as the square root of the radius of the outer circle, so that the last of the minor set will be equal to the unit for the major; that is. of the set of major and minor circles, the major begin where the minor leave off.

What has this to do with the solar system?

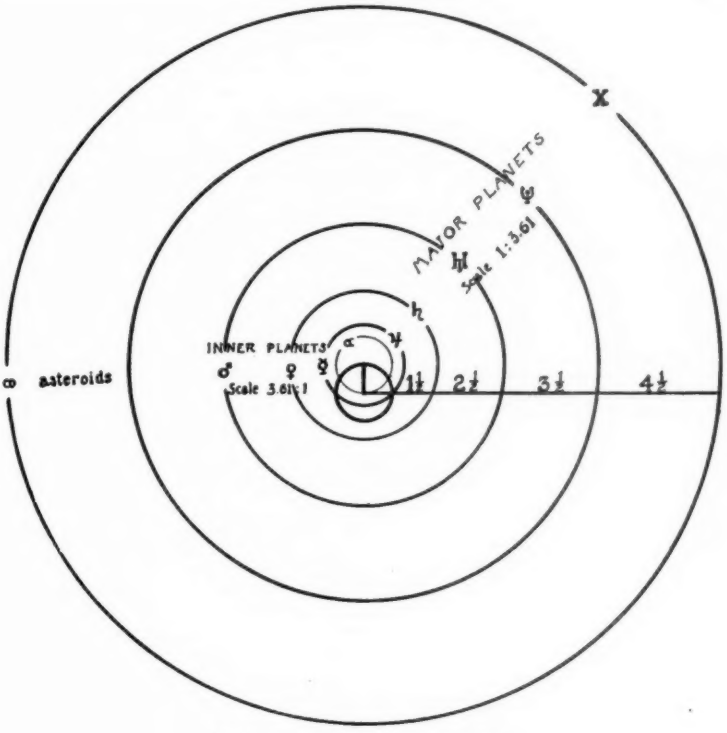
We calculate the lengths of our set of radii, and of the major and minor sets derived from them. In the table, n is the number of the point, R_n the length of the produced radius to that point, r_n the radius from the new center, while the last two columns give the minor and major sets of radii.

n	R_n	r_n	$r_n/\sqrt{13.038}$	$r_n\times\sqrt{13.038}$
1	1.00	1.414	.392	5.093
2	2.50	2.693	.746	9.689
3	5.00	5.099	1.412	18.373
4	8.50	8.559	2.367	30.774
5	13.00	13.038	3.610	47.067

We tabulate these major and minor radii against the data of the solar system:

r	Mean Distance	Planet	(Corr. to r)/r
.392	.387	Mercury	—.013
.746	.723	Venus	—.033
1.412	1.524	Mars	.071
2.367		[asteroids]	....
3.610		[unit circle]	....
5.093	5.203	Jupiter	.023
9.689	9.539	Saturn	—.016
18.373	19.191	Uranus	.044
30.774	30.071	Neptune	—.023
47.067	45-50	new	±.0

*In the accompanying diagram, a sixth circle through this point has been drawn for geometrical clarity; no planet is associated with this circle.



(Radius of inner circle α is unity.)

The earth does not appear in this tabulation, but its mean distance is the unit —not arbitrary, but chosen to make the minor and major systems coalesce (at the point 3.610 where there is no planet). The physical significance of this unit is the same as that of the rest of the representation, probably nil; its significance is geometrical.

We have a system which exhibits the planetary progression beautifully and simply. It embraces the distinction between the inner and major series of planets, and the relation between them. Without introducing any arbitrary factor, it makes the radius of the earth's orbit the fundamental unit required to make the two series coalesce. The accuracy of the representation cannot apparently be exceeded by any simple formula; the planets adhere to it as well if not better than to circularity of orbit (eccentricities range to .09 and .20 for Mercury) or to coincidence with ecliptic plane. The uniqueness of the earth is (at least) appropriate; if we did not have an earth, we could not become acquainted with the solar system.

If there is any physical parallel to this diagram, it lies perhaps in the formation of the solar system from two tidal effects, similar but of different size, each

dividing up progressively, the formation of the earth being a sort of miracle provided, presumably, especially for our benefit.

Between the orbits of the two absent inner planets lies a band of small bodies, a "Saturn's ring" of the solar system. These two lesser ones perhaps tried to be major planets, and succeeded only in becoming asteroids.

This system is advanced in the hope that it will replace the discredited formula of Bode in the minds of those who seek to draw all possible harmonies from the progressions of nature.

HERBERT HARVEY.

North Hackensack, New Jersey.

Aurora Observed. —On the evening of March 17 there was a display here of the aurora and zodiacal light about 8:15 o'clock P.M. The aurora center in the northeast was fairly distinct and in the form of a sector of a circle. The Zodiacal Light was the most distinct that I have ever seen, the two being in the sky at the same time being very spectacular. I was wondering if you have any record of this phenomenon occuring before in this manner.

GEO. F. SHEA.

Billings, Montana, March 19, 1930.

GENERAL NOTES

Dr. J. S. Plaskett, director of the Dominion Observatory, Victoria, B. C., has been awarded the gold medal of the Royal Astronomical Society for his valuable observations of Stellar Radial Velocities and the important conclusions derived from them. Dr. Plaskett is to deliver the George Darwin lecture at the meeting of the Society on May 9. The subject of his lecture is to be "The High Temperature Stars."

Mr. D. B. Pickering, formerly president of the A.A.V.S.O., has recently returned to his home in New Jersey after spending some months in Florida. While there Mr. Pickering found occasion to continue his work in making charts for variable star observing and also for transmitting his enthusiasm for this work to amateur astronomers in Florida.

Dr. Harlan T. Stetson, director of Perkins Observatory of Ohio Wesleyan University, addressed the Non-Biological section, at the Tenth Annual Ohio State Educational Conference, on "What are the Stars?" Other speakers on the program included Professor Arthur H. Compton, of the University of Chicago, who gave a demonstrated lecture on "What is Light?", and also Saul Dushman, of the General Electric Company, whose subject was "An Interpretation of the New Mechanics."

Professor Albert A. Michelson has returned to the University of Chicago, his health much improved after two months spent in Bermuda. He intends to remain at Chicago for several months, working in the Ryerson Physical Laboratory, and then plans to go to California to continue his measurements of the velocity of light in a mile-long vacuum tube. (*Science*, March 28, 1930.)

L'Illustration, a beautifully illustrated magazine published weekly in Paris, recently contained extensive articles and pictures related to astronomy,

prepared by Professor G. W. Ritchey. The issue for December 21, 1929, contains photographs of some of the largest telescopes in this country and a number of excellent large scale reproductions of photographs of nebulae taken by Professor Ritchey. The series is continued in the issue for January 18, 1930. These very fine plates exhibit at the same time the great skill of three persons who are involved in the making of them, the photographer, the engraver, and the printer.

Amateur Astronomers Association of New York City carried out the following program during the month of April. April 2, illustrated lecture by Mr. Weld Arnold, subject, "Where are you and how do you know?" April 23, illustrated lecture by Professor S. A. Mitchell, subject, "One thousand and one stars—their distances."

Junior Astronomer Examination. — Applications for junior astronomer must be on file with the Civil Service Commission at Washington, D. C., not later than May 20, 1930. The examination is to fill a vacancy in the Naval Observatory, Navy Department, Washington, D. C., and vacancies occurring in positions requiring similar qualifications. The entrance salary is $2.000 a year. Higher-salaried positions are filled through promotion. Competitors will be rated on mathematics including algebra, geometry, trigonometry, plane analytics, calculus, and mechanics; elementary questions in general and spherical astronomy and related branches of physics; and practical computations including the use of logarithms. Full information may be obtained from the United States Civil Service Commission at Washington, D. C., or the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

Astronomy by Radio. — A second series of lectures on astronomy was broadcast by station WTAM, Cleveland. These talks were given by Dr. O. L. Dustheimer, professor of astronomy, at Baldwin-Wallace College, Berea, Ohio, from 6:15 to 6:30 on: Tuesday, April 1, The Ninth Planet; Thursday, April 10, The 13 Month Calendar; Tuesday, April 15, The Evening Star; Thursday, April 24, The Solar Eclipse.

The first lectures, given in the "School of the Air" program, were:

Nov. 7, Astronomy, The Oldest of the Sciences; Nov. 21, The Sun, Our Nearest Star; Dec. 5, The Moon, The Earth's Satellite; Dec. 19, The Planets, The Children of the Sun.

In addition to the above, WTAM conducts a Star Gazer's Club. Special maps for each month are sent to members. There are more than 2000 members from 35 states and several Canadian provinces in the WTAM Star Gazer's Club.

Astronomy Lectures for the Public.—A series of four talks on Astronomy has been recently given at the Perkins Observatory at Delaware, Ohio, by Dr. H. T. Stetson, director of the Observatory.

The dates and titles of these talks follow:

1. February 26, at 7:30 p.m., "The Wandering Planets."
2. March 10, at 7:30 p.m., "Our Neighborhood World—The Moon."
3. April 9, at 8:00 p.m., "What We See Through a Telescope."
4. May 6, at 8:00 p.m., "Sunlight, Moonlight, and Starlight."

Accommodations have been limited to 100 each evening, admission being by ticket only. After the lecture, opportunity for viewing the moon or one of the

planets was offered if the sky was clear. In the event of weather unfavorable for observation, a complete demonstration of the working of the large telescope was given, this mechanical demonstration of the instrument being necessarily omitted on clear evenings, as the telescope was then fixed on the object for observation for the evening.

Zodiacal Light Notes

A copy of the New Zealand Astronomical Society's "Notes" for 1930, February, has been received from Mr. Ivan L. Thomsen, Dominion Observatory, Kelburn, Wellington. It reports observations made by Messrs. I. L. Thomsen, A. G. C. Crust, and E. B. Jones. On August 1, 1929, Mr. Thomsen estimated the breadth along the horizon at 25° and extension along the ecliptic about 65° through Leo almost to Spica. Observing at 7:05 G.M.T. on the same date Mr. Crust noticed that the main body seemed to have moved slightly south as compared with observations in July. He also observed that the north edge was noticeably sharper than the south boundary. On August 27 he found the outer cone extending to Alpha Librae. Mr. Jones's observations during September and on October 2 showed that the first appearance of visibility of the Light corresponded exactly with that of the Milky Way. At the end of September the apex was in Scorpio but it could not be determined because it was intermingled with the light of the Milky Way.

From Mr. Sterling Bunch, U. S. Weather Bureau, Knoxville, Tennessee, reports of observations on March 20 and 22 have been received. He found the main body of the Light 3° 25′ and 3° 50′ north of the ecliptic on the respective dates. Giving the Milky Way in Cassiopeia and Perseus a rating of 1.0 for brilliance he estimated that of the Zodiacal Light as 1.5 and 2.0 on the two evenings respectively. The writer observed the Light on March 3, 4, 17, 20, 21, 22, 23, 28, 29, 31, and April 2. During this period the unusual brilliance of the Light this season was maintained. On April 2 with the moon four days old the Light was sufficiently strong to be seen along the central axis from the horizon to the Pleiades. On March 23 the white painted masonry guarding the side of a culvert and facing west was brought into clear relief and leafless branches of a small tree stood out like an etching with the Light as a background. During this period also the southern boundary was seen to be sharp edged.

Gegenschein. The Gegenschein was seen on March 21, 23, 28. On March 23 a filmy band was discerned along the ecliptic from Regulus to the horizon, the Gegenschein appearing as a very elongated ellipse. The identity of the band and the Gegenschein was demonstrated by contrasting it with the dark sky on both sides. At midnight the Gegenschein showed distinctly, its boundary being diffuse, the estimated major diameter along the ecliptic, about 20°. On March 28 at midnight the Gegenschein was seen north of Corvus.

Aurora. On March 21 an auroral glow, beehive in shape, surrounded the northern horizon at 11:00 P.M. Its center was slightly west of the meridian and very faint streamers extended upwards to Camelopardalis. At 11:30 the aurora levelled down to a band about 8° in breadth along the horizon and was then relatively faint. It brightened considerably at 11:40 and again paled at midnight.

W. E. Glanville.

The Rectory, New Market, Maryland.